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TABLE OF CONTENTS.

LEADING ARTICLES: Page.

Gasoline-Electric Car of the Buffalo, Rochester & Pittsburg R. R. (illustrated) 551

The Rusting of Iron; A. H. Sabin 551

An Improved Valve and a High-Pressure Pipe Joint (illustrated) 553

The Manufacture and Properties of Hydrated Lime (illustrated); Richard K. Meade 554

A New Design of Blower for Increased Efficiency (illustrated); A. H. Anderson 558

Some Conditions Affecting Higher Education; W. D. Taylor, M. Am. Soc. C. E. 559

Comparative Tests of Large Engine and Turbine-Driven Centrifugal Pumps (illustrated); Francis Head, M. Am. Soc. M. E. 562

The Security of Irrigation Bonds; Walter E. Lagerquist 563

A Storage-Battery Truck for Handling Package Freight in Railway Freight-Houses (illustrated) 564

A Self-Closing Safety Crane Hook (illustrated) 565

The Mechanical Handling of Package Freight (illustrated); M. B. Waterman. 566

Comparative Radiation of Heat Through Solid and Air-Space Boiler Settings.. 568

Members of the American Institute of Mining Engineers on the Panama Canal Work 580

The New Water-Supply Tunnel Under New York City 581

EDITORIAL 569

Efficiency in College Teaching—The Conflagration at Bangor, Me. (illustrated) —The Mining Engineers on the Choice of the Lock Canal for Panama—Low Cost Records on the Culebra Cut in March—The Contract for the Deep Tunnel Under New York City—The McGrath Bill for Licensing Engineers Again—A Caution to Those Who Answer "Want" Advertisements.

The Slides on the Panama Canal (illustrated) 570

LETTERS TO THE EDITOR 574

The Inventor of Portland Cement; Alfred S. Johnson—Concerning the Design of a 10-in. Gate-Valve Casing; Phil De Clamecy—Making a Profession of Engineering: The President of the Technical League on License Laws for Engineers; W. G. Eliot—The Best Way to Show a Weld in Cross-Section (illustrated); C. F. Gailor—Photography for the Engineer; Henry Wells Durham—A Proposal to Extend Manhattan Island Four Miles Down New York Bay (illustrated); T. Kennard Thomson—Social Philosophy and the Taylor System Methods; Winslow H. Herschel—Radius-Bar Length and Swing of Locomotive Trucks (illustrated); William E. Ninde.

ENGINEERING NEWS OF THE WEEK 583

PERSONALS 584

ENGINEERING SOCIETIES 584

Gasoline-Electric Car of the Buffalo, Rochester & Pittsburg Ry.

On April 18 the car shown in Fig. 1 made the trip under its own power, from Schenectady to Rochester, N. Y., 244 miles, over the tracks of the New York Central & Hudson River R. R., with a party of railway and electrical engineers aboard. The trip was made on time at every point along the journey and without delay of any kind.

This car is intended for branch-line service where there is need of reducing operating expenses for light-traffic hours. The car is 66 ft. long, 14 ft. 1 in. high, and has a seating capacity of 49 in the passenger compartment and 20 in the smoking compartment, with two passengers per seat. The seats are sufficiently wide to accommodate three persons, so that the maximum seating capacity may be given as 97. By having center doors, the closed end construction is possible. Forward from the entrance are the smoking, baggage and engine compartments respectively. A long seat is placed across the closed rear of the passenger compartment, to make an attractive observation end.

The power is generated by a 175-HP. gasoline engine, driving an 80-KW. direct-current generator at 550 r. p. m., and is transmitted to standard railway motors on the trucks. The speed control is similar to that of the ordinary electric car. A 160-gal. storage tank carries gasoline for a run of 200 miles. Automatic and straight air-brake equipments and an auxiliary hand brake are provided. The car was built for the Buffalo, Rochester & Pittsburg Ry. by the General Electric Co., of Schnectady, N. Y.

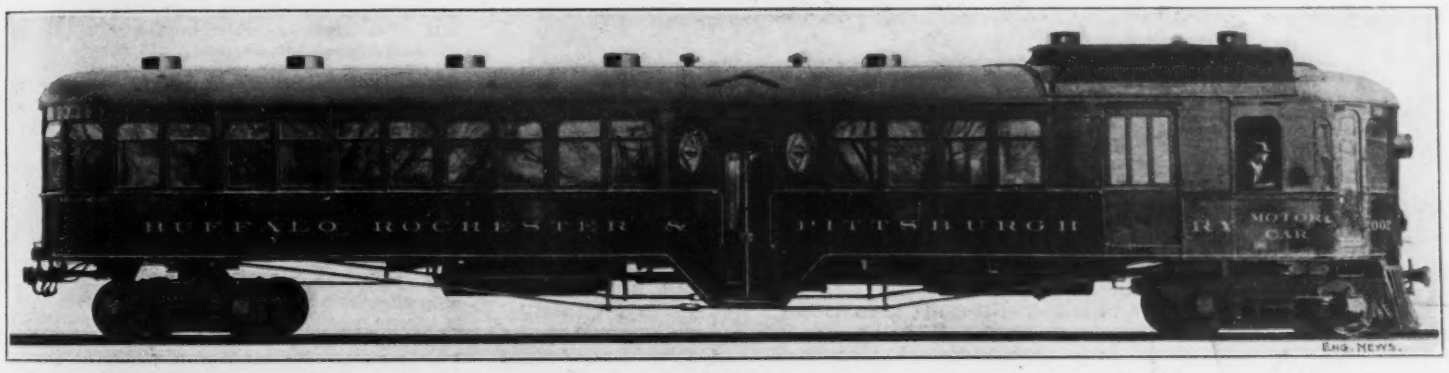

FIG. 1. GASOLINE ELECTRIC MOTOR CAR BUILT BY THE GENERAL ELECTRIC CO. FOR THE BUFFALO, ROCHESTER AND PITTSBURG R. R.

The Rusting of Iron.*

By A. H. SABIN,† M. Am. Chec. Soc.

The destruction of iron by rusting is no new thing. Once in a while some active-minded person discovers something new about it, or at least invents a new way of saying what some one had said before. Whereupon, he proceeds to reason more or less lucidly on some limited phase of the subject, and for a time is inclined to assume the position that nobody need worry any more about the corrosion of iron. If they will refer their troubles to him, he will dispose of them, preference being given only to those who come first. After a few years, however, he begins to doubt, not his theory which is all right, but its application to practice by those who are not adept. In a few years more, he is willing that any later discoverer should grapple with some of the more refractory problems, such as smoke-jacks in roundhouses or iron piling for piers in sea-water. It is much to the credit of human nature that the later discoverer is always willing to tackle these things.

There are two theories to account for the rusting of iron. The older of these may be called the acid theory. It is often called the carbonic-acid theory, but that is only because carbonic acid is the most common acid. It applies to any acid. According to this theory, iron, if exposed to pure water and pure oxygen, will not rust. But if a trace of acid is present it attacks the iron, forming a soluble ferrous salt which then is decomposed by the oxygen into insoluble ferric oxide (hydrated), and the acid transfers itself to a fresh portion of metallic iron. Action of this sort is called catalysis, and the acid is said to act as a catalyzer.

Those who uphold what is called the "electrolytic" theory, on the other hand, maintain that if iron is put into pure water and oxygen it will rust. They say that water consists essentially of the compound H_2O, but that all such compounds contain minute amounts of uncombined or only partially combined elements, and that hydrogen and hydroxyl, OH, are dissolved in the true water. These are supposed to be fragments of molecules which have been broken up by electrical action, and all such electrically produced molecular fragments are called ions. This theory thereupon assumes that when a piece of iron is brought into contact with water, an atom of iron combines with two ions of hydroxyl to form a molecule of ferrous hydrate, FeO_2H_2, with the elimination of two ions of hydrogen which may form a molecule of hydrogen, H_2. Then the addition of oxygen causes the ferrous hydrate to become ferric hydrate, which is insoluble, and is visible as rust. According to this, no catalyzer is needed.

It would seem easy to determine which of these theories is true. All we have to do is to put some iron into water which contains no acid and see if it rusts. But it is difficult to know whether water contains acid or not. It is customary to tell this by the use of litmus or other solutions, which change color if acid is present. But an appreciable amount of acid is necessary to make this change of color so pronounced that the eye can recognize it and, according to theory, a single molecule or a relatively small number of molecules of acid will be sufficient to produce a visible rusting effect in a few hours. When we consider that molecules are so small that it would take several millions of them in line to reach a quarter of an inch, it will be obvious that millions upon millions of them would be necessary to produce a litmus color change which would be recognized by the eye. We have absolutely no means of detecting the presence of very minute quantities of acid.

Again, it may be said that since the presence of free ions assumes that pure water is a conductor of electricity, we may determine experimentally whether water does conduct electricity or not; if not, then there are no ions, and that theory goes to pieces. But here again we find it impossible to prepare pure water on which to experiment. Ordinarily pure water is a very poor conductor of electricity. Chemists have been to great pains to prepare water of very exceptional and high

*From a paper before the Brooklyn Engineers Club, April 27, 1911.

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purity and such water has enormously greater non-conducting qualities than ordinary water. If such water be exposed to the air for a very short time, its conductivity is increased many times, probably by its taking carbonic acid into solution; and not a few chemists maintain that if absolutely pure water could be obtained, it would be found to be incapable of conducting an electric current, or in other words, would be incapable of ionization. The addition to water of an acid or acid compound, called an electrolyte, to make it a better conductor, is an old and well-known practice; and it is thought by many that, if absolutely all electrolytes were removed, the water would be a non-conductor.

As has been said, the acid theory of corrosion is the older. So the so-called electrolytic theory is just now the more fashionable; and if an ordinary, every-day paint chemist questions any of the pretensions of some of those who are upholding it, he is liable to be considered as seditious.

It cannot be too emphatically said, that the rejection of what is called the "electrolytic" theory of corrosion has nothing to do with belief in the general electrolytic theory of chemical action. The acid theory of corrosion is in perfect agreement with the general theory; what is called the electrolytic theory of corrosion is a particular term which has been appropriated for the specially limited theory which has been described. In a broad and general way, all chemical action may be described as electrolytic, in the sense that chemical changes are accompanied by electrical action. One of the oldest and best-known methods of producing an electric current is by the action of acid on metal. By the action of an electric current on oxide of iron (or other metal), it is possible to prepare the metal; and the metal may be said to be a source of potential electrical energy, in the sense that a weight raised to a height is said to have energy of position. It has long been known that rusting is accompanied by, and may be induced by, electrical action; and anyone who claims to have discovered this is unworthy of serious consideration.

Theories are of use to help us to understand facts. If they put our minds in such condition that we invent unrealities and call them facts, they are harmful. This may seem absurd, but it is really common. It is not wise for anyone to assume that whoever does not accept his theory is therefore ignorant.

We have heard much in the last two or three years about inhibitors and stimulators among pigments. Personally, I do not believe there is anything in it. This belief cannot be thought to be inspired by jealousy, since the theory originated in experiments first made in our laboratory, and was tentatively suggested by my colleague, Mr. G. W. Thompson, Chief Chemist of the National Lead Co.; and when the present hysterical outcry about it is over, it may lead to some increase in our knowledge of pigments and of paints. Briefly, it is founded on the behavior of pigments mixed in water, with access of air, and in contact with pieces of metallic iron.

One of the most conspicuous results is that lampblack and other carbon pigments cause, in these watery mixtures, rapid rusting. Obviously, this is probably due to the fact that these pigments are likely to contain excessive amounts of carbonic acid, probably as absorbed condensed gas, or because, being in very fine condition, at least in part, they oxidize into that acid and go into solution, a state of things which does not take place in a non-solvent and insulating medium like oil. Other stimulators are precipitated barium sulphate, which naturally contains traces of acid, bright red iron oxide, which frequently contains considerable amounts of acid and acid Prussian blue. All these furnish acid to water, and make a corrosive solution.

The chromates, on the other hand, are "inhibitors." They furnish chromic acid, which has always been known to induce the so-called passive condition of iron, in which it is indifferent to chemical action. The enthusiastic experimenters point to the good results obtained with paints made from certain chromates; there is no reason why these chromates of the heavy metals should not be good pigments. In fact all we know about them is in their favor, except that their price is prohibitory; but when they are asked to explain the equally good or superior condition of most of the paints made with the so-called accelerators, they look wise and say that no doubt they look well on the surface, but that they are rusting underneath; like Mr. Pickwick's warming-pan, they are a mere cover for hidden fire. All of which seems to me highly absurd.

If anyone questions the validity of the experiments he is asked, "But don't you believe in the electrolytic theory?" If he says yes, he is told that settles it, for this inhibitor and stimulator theory agrees with that theory, and if one is true, the other must be; if, on the other hand, he expresses doubt, he is no better than one of the wicked, and unworthy of either instruction, doctrine or reproof.

The so-called "electrolytic" theory of corrosion has nothing to do with it, nor has it very much to do with the general problem of preventing rusting. There is nothing in that theory inconsistent with the perfectly well-known fact that carbonic or other acids stimulate corrosion, and that the engineer's problem is how to keep moisture, air, and acid gases away from the surface of the metal. These are the essential points. As to securing these results, there are differences of opinion; but the differences are slowly becoming less. That is, there are more points on which there is substantial agreement.

It must be remembered that, in most cases of rusting, the metal is exposed to the air and that the air always contains oxygen, moisture, carbonic acid, and very often, sulphuric acid, in quantities ample to account for rusting. Therefore, we are practically called on to exclude the air as much as possible, although if we can also, as a secondary consideration, lessen its effect, that is desirable.

This, it is well-known, may be to a large degree effected by galvanizing. The coating of zinc protects the iron, since the corroding gases and liquids will attack the zinc first. There is no doubt in my own mind that red lead owes much of its merit to a similar quality; it is a metallic oxide ready and eager to enter into union with any acid substance, which latter is therefore neutralized before it can penetrate the coating. Unlike most such coating material, the salts of lead thus formed are obstinately insoluble. Sulphuric and sulphurous gases and even hydrogen sulphide form very insoluble salts with lead. Chlorine compounds, so common in the air near the ocean, make insoluble lead chloride; carbonic acid merely changes it, superficially, into white lead, which is a pretty good paint in itself. The whitening of structures painted with red lead is due to these actions. In none of these cases does the pigment become soluble and wash off. It remains there and mechanically acts to prevent the corrosive gases from access to the interior layers of the paint, which therefore decays very slowly. The sulphates and chlorides of other metals, on the other hand, are highly soluble. So are those of calcium, which is often an ingredient of paint in the form of sulphate or carbonate, both soluble salts.

Barium sulphate (barytes) on the other hand, is very insoluble and, although it could not be expected to have any protecting action by absorbing acids as red lead probably does, it might be expected to be a good neutral pigment which would afford excellent mechanical protection. This, however, does not prove to be the case. Rather the opposite is true. Iron rusts worse under a straight barytes paint than with perhaps any other. This may be due to the fact, well known to chemists, that, in the presence of other salts, barium sulphate is decomposed, even at ordinary temperatures, in a very small but perfectly distinct amount. Also, as I have recently shown, it has a marked action on linseed oil. We have for many years been accustomed to speak of barytes, silica, and the silicates as inert pigments. This has seemed warranted by their general chemical stability but, in fact, they act on oil with not merely appreciable but with considerable effect. In some respects they act much more than does zinc oxide or white lead.

It is probable that we shall find that one of the most important qualities of a pigment is its surface attraction for oil, which is essentially related to capillarity and that, in a good paint, there must exist a friendly relation, so to speak, rather than a destructive or repellant one, between the pigment and the vehicle. This affinity is shown, among other things, by the readiness with which a well-constituted paint dries to a normal, elastic film, hard but not brittle, and needing little or no drier to make it dry properly. Extremely slow drying has always been noted as a bad quality and so has the use of an excessive amount of drier. The many good qualities of some of the carbon pigments are to some extent counterbalanced by their imparting to mixtures with oil this extreme non-drying property.

It has already been said that it is no theory nor assumption but a fact many times proved and not questioned, that the air, which causes rusting, contains water and acid. It may also be said that corrosion is, in practically all cases, local and not general in its beginning. That is, it does not begin with a uniform film of rusting but by pitting at small local centers. This is different from the way, for example, that a good paint perishes, which is shown in the loss of thin superficial films, indicating that not only is the air of constant composition, but also that the paint is of uniform character.

Iron, on the other hand, is thus shown to have varying components or structure, so that one spot rusts while the surrounding surface remains intact. It has been pointed out that the normal structure of iron and steel is crystalline; that metals conduct electricity better if they have a crystalline structure; that increased conductivity implies better resistance to corrosion and that the heterogeneous structure which results from straining beyond the elastic limit produces unequal electric conductivity and thus induces corrosion.

In the case of iron it is well-known that, when strained beyond its elastic limit, it is far more subject to corrosion than before. On the other hand, it has been observed that when placed under a moderate strain it resists rusting better than when unstrained. Recent very instructive experiments (by Shaffer) show that this resistance increases with the strain up to a certain point, far below the elastic limit, and then decreases as the strain becomes greater. All these facts support the theory that susceptibility to corrosion is not to be sought so much in chemical as in physical structure, and that if modern metal is much worse in this respect than was formerly the case, the trouble is probably due in great part to rolling or otherwise deforming it at a speed so high and a temperature so rapidly lowering

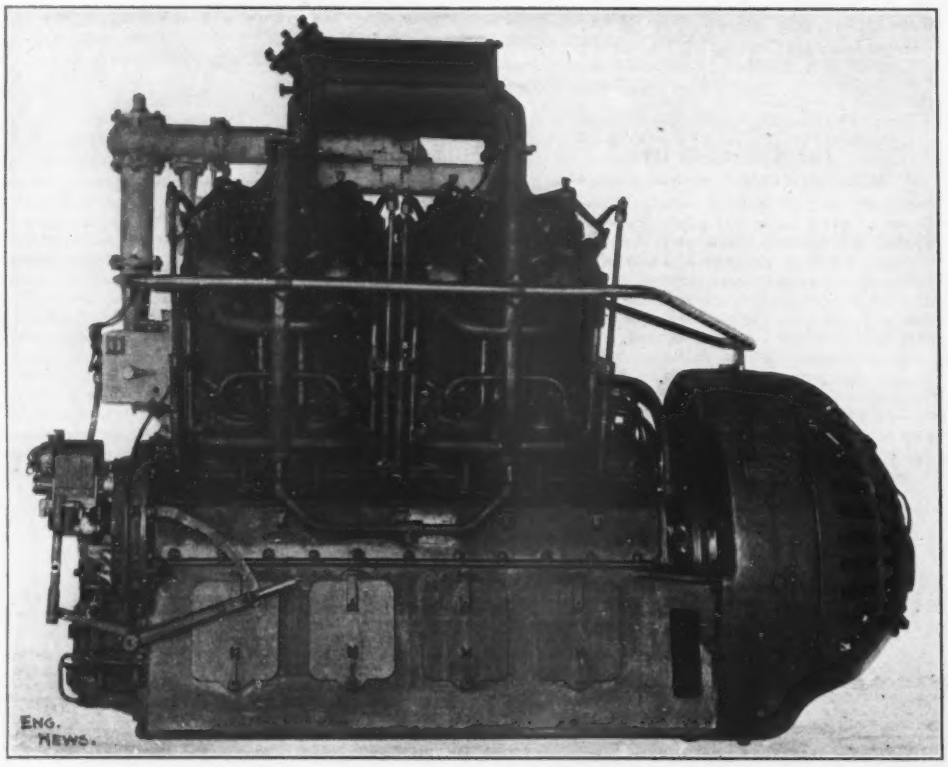


FIG. 2. ENGINE-GENERATOR SET OF GASOLINE-ELECTRIC MOTOR CAR, BUFFALO, ROCHESTER AND PITTSBURG R. R.

that the molecules do not have time to arrange themselves properly, whereas formerly, using much less force, the metal was worked at a high temperature, slowly, and allowed to cool naturally. A less tonnage was put out, per unit amount of capital invested, and it cost more but it was better. Slow working tends to greater compactness, less porosity. In making welded pipe the part along the weld is compressed and it does not rust as rapidly as the opposite side of the pipe.

In all that has been said, the term "iron" is used for both iron and steel. Difference of opinion exists as to the relative merits of these. In most long-time tests, iron pipe has been superior to steel pipe but in laboratory and short-time tests steel is the better. It has been suggested that as steel pipe is of superior tenacity now to that formerly made it is also more homogeneous and therefore better and that as all the short-time tests have been on recently made pipe, and the long-time tests on old pipe, it shows a relative change in durability. This evidently introduces still another factor into the problem.

Certain engineers and chemists maintain, with great emphasis, that iron or steel embedded in concrete is necessarily secure against rusting. Concrete is certainly alkaline, and alkali in general hinders corrosion of iron. It is easy to construct a plausible theory to show the impossibility of rusting under such conditions but almost anything can be done in theory. In the tests by Shaffer, already mentioned, a current amounting to only 1/1000 amp., at a pressure of 2.5 volts, passed through 3 ins. of 1:3:5 concrete, which was placed in salt water, causing very serious and active rusting. It appears that while, in some cases, iron does not rust in concrete, in other cases it does rust. In fact, a current of 1/60 amp. was sufficient to generate enough chemical action to split a block of concrete in about four months.

Inasmuch as nearly all reinforced-concrete buildings are wired for electric currents of over 100 volts, it would seem advisable to give them some further protection than is afforded by concrete. If the latter is dry it is much more likely to protect; but in foundations especially this is not certain to be the case, and in these places the permanence of the reinforcement is a matter of the greatest importance.

Aside from concrete, the only protection which is given to structural metal, to any great extent, is by painting. It has always been claimed by paint manufacturers that such protection as paint affords may be varied several hundred per cent. by the care and intelligence used in its application. If the same care were used in painting a steel structure that is employed in painting an ordinary house, the steel would get, on the average, immunity from rust for twice as long as it does now. Paint probably adheres to a metal surface in the same way that other things do, and the conditions which favorably influence the adhesion of other coatings are desirable in its use; and, with due allowance for the impermeability of metal, the principles which govern its application to all other surfaces apply to its use on iron and steel. Steel is in most situations more perishable than wood, and should receive at least as much protection.

The first and most important thing is to have a clean surface. For nickel or copper plating, the surface must be chemically clean; so also for enameling or japanning. If everything else requires a clean surface, it is reasonable to demand it for paint. Steel is often covered with rust, and not infrequently with mud and other dirt. No one would try to paint a board if it were covered with a layer of decayed wood; all dirt is thoroughly cleaned away and even old paint is removed, unless it is in good condition. Why should we suppose that paint will stick to iron in conditions not allowable elsewhere?

In 1906, a committee of the American Society for Testing Materials applied 19 kinds of paint to portions of a new railroad bridge at Havre-de-Grace, Md. The surfaces to which these paints were applied were not pickled nor sandblasted; but they were made as clean as they could be without these or similar operations. They were very fairly clean. Then the paint was applied with care and skill, in favorable weather. Nearly all these paints are still in good condition, and in most cases there is reason to suppose that they will not need renewal for several years to come. This clearly proves what has just been said: No one can suppose that these 19 commercial paints are of equal value, and the chances are that some of them are of but indifferent quality. A moderately good paint, well used, will give better results than the best paint carelessly applied.

UNLOADING PIG-IRON WITH MAGNETS slung from the trolleys of a conveyor of the bridge type has been tried at the plant of the Inland Steel Co., at Indiana Harbor, Ind. A cargo of about 2,000 tons was unloaded in 10½ hours by the use of two Cutler-Hammer lifting magnets, and the vessel was at the dock only 12 hours. The number of lifts was from 45 to 73 per hour; the total number of the lifts for the two magnets was 1,281, with an average load of 3,427 lbs. The work requires a smaller number of men than when buckets are used.

An Improved Valve and a High-Pressure Pipe Joint.

Tight valves are necessary for the economical service of pipe systems carrying steam, compressed air, water, gas, ammonia or other fluids. Leaky valves involve loss of fuel, power, etc., besides causing objectionable conditions; further, they are liable to result in interruption of service, or even the temporary shutting down of a plant, while necessary repairs or renewals are being made. A very common cause of valve

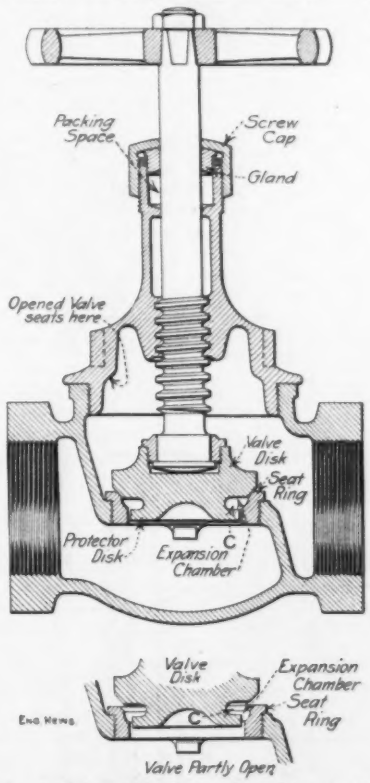


Fig. 1. A Valve with Protector Device to Prevent Cutting of the Seats.
(The Osborne High-Pressure Joint & Valve Co., Chicago; Makers.)

wear and leaky valves is the cutting of the seats by the wire-drawing of the steam or other fluid in passing through the narrow annular opening between the disk and seat at the time the valve is just opening or closing. When the surfaces are once attacked, the wear or cutting increases rapidly.

To meet this condition there has been designed the Osborne valve, in which this cutting action is transferred to a protector disk on the bottom of the valve disk and to the lower part of a renewable seat ring in the valve body. The protector alone would do but little to relieve the valve from wear, but an additional and special feature is an annular recess or expansion chamber formed between the protector disk and the valve disk proper. The effect of this chamber is to reduce the wire-drawing very materially. The construction is shown in the sectional drawing Fig. 1. The valve disk has at its lower end the protector disk and expansion chamber. The renewable seat ring has a loose or slip fit for the protector disk, and the valve seat is on the faced and beveled upper surface of the ring. With the valve just clear of its seat, as shown in the detail drawing, the annular space between the seat and the side of the expansion chamber is much wider than that between the protector disk and seat ring. Consequently, in opening, the sharp flow or wire-drawing through the latter opening is very much reduced in the former and wider opening. In closing, also, the protector disk takes the wear in shutting off the flow, and (with the aid of the expansion chamber) permits the valve to seat easily under balanced or greatly reduced pressure.

The valve can be packed without shutting off the flow in the pipe. When fully open, the valve makes a tight joint against the bonnet; in this position, therefore, the cap can be unscrewed and the gland and packing removed without danger. Where a flat seat is required the bottom face of the valve disk has an annular insert of a special soft metal.

Valves on this principle are made for a great variety of purposes, and have been put in service under severe conditions. Their special advantages, of course, are where the valves are operated frequently. On a pipe line carrying hydraulic pressure at 750 lbs. per sq. in., where the valves were continually being opened and closed, an ordinary valve was very badly cut in 10 days' service, while an Osborne valve was in good condition after 56 days. All the wear in the latter case was a slight beveling of the lower edge of the protector disk. These valves are in use for steam (including superheated steam), water, oil, carbon-dioxide gas, ammonia, etc., at pressures of 5 to 5,000 lbs. They have been applied to water columns, pump throttles, boiler checks, flue blowers, blow-offs, radiators, etc. In the blow-off valve, the protector holds back the sediment and scale in the pipe until the valve seats are so far apart that the scale can be passed through without injuring them. Radiator valves are of the flat-seat type; when closed the water of condensation forms a water seal in the expansion chamber, preventing any leakage of steam and consequent accumulation of water in the radiator.

Another device is the Osborne pipe joint for high-pressure service. This is shown in Fig 2. It is of the flanged and bolted type, but its tightness does not depend upon any joint on the thread of the pipe or between the flanges. The end of each pipe is threaded and upon this is screwed the flange, but the threads serve simply to hold the parts together. On the smooth end of each pipe (the threads being milled off at this point) is a packing ring, wedge-shaped in section. Between the two packing rings is fitted a steel joint ring, its edges resting beneath ribs on the flanges. Bolts are put through the flanges. As the bolts are tightened, the packing rings are compressed between the inclined faces of the flanges and joint ring and are forced tightly upon the pipe. The construction is such as to prevent any blowing out of the packing. Leaks may be taken up by tightening the bolts. The joint is sufficiently flexible to take up any slight inaccuracy in the line of the pipes.*

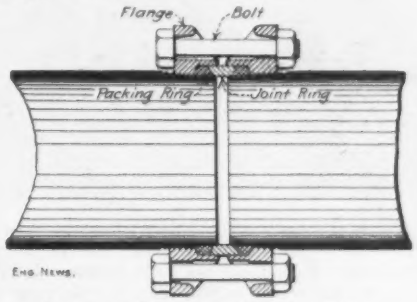


Fig. 2. A High-Pressure Pipe Joint.
(The Osborne High-Pressure Joint & Valve Co., Chicago; Makers.)

The valves and pipe joint described above are the invention of the late E. F. Osborne and his son, W. L. Osborne. They are manufactured by the Osborne High-Pressure Joint & Valve Co., Rookery Building, Chicago.

AN EXPERIMENTAL COAL FUEL ENGINE is provided with a gas generator, which consists of several parallel pipes passing through an exhaust-heated chamber and the back of the combustion chamber. Through this powdered coal is mechanically pushed, the gas given off passing into a miniature gasholder in which the pipes terminate under a water seal. From the holder the gas is drawn off by cylinder suction. The inventor has made such tests as are practicable with the engine in its experimental state, and obtained with short continuous runs a coal consumption of under 0.4-lb. per brake-horse-power-hour.—London "Engineering."

*Some bolted flange joints for high-pressure steam in marine work were described in our issue of Aug. 29, 1901. A flange union joint with brass ring and no gasket was described in our issue of Aug. 29, 1907. A pipe joint for superheated steam, shown in our issue of June 13, 1907, has the pipe ends flanged outward and held together by bolted sleeve flanges.

The Manufacture and Properties of Hydrated Lime.

By RICHARD K. MEADE.*

The compound composed of calcium oxide, popularly known as lime, and water is called calcium hydrate or more familiarly, "hydrated lime." To a product which is made by mechanically slaking lime, the name "hydrated lime" is therefore appropriately given. This consists of a dry fluffy powder, nearly all of which will pass through a very fine screen and which is essentially calcium hydrate and magnesium hydrate mixed with a greater or a less amount of such impurities as silica, iron oxide and alumina.

Theoretically, 56 parts of lime unite with 18 parts of water. If more than 18 parts of water is added to 56 parts of lime the quantity of water in excess of 18 parts will either be driven off by the heat generated, which amounts to 1,500 calories per kilo (= 2,700 B. T. U. per lb.) of lime, or if much in excess will remain with the slaked lime. The excess of water of course does not combine with the lime, but merely exists as water, forming with the slaked lime a wet mass or putty. This is what takes place when lime is slaked by the mason in the mortar box. If the proportions of lime and water are exactly or nearly 56 to 18 and the mixture of lime is thoroughly worked so that the slaking is complete, all the water is absorbed by the lime and the product is a dry powder. This dry slaked lime is the "hydrated lime" of commerce.

For quite a number of years there have been upon the market crude products which resulted from the slaking of the lime in piles on the ground or floor by the application of water. In most instances, the water added was insufficient to change all of the lime to hydrated lime and some of it always remained as the oxide. Some carbonate was also always formed and if the lime was air slaked this carbonate was considerable. These limes, generally speaking, did not give satisfaction for mortar purposes, owing to the fact that the hard burned portions would not slake by such treatment. These so-called hydrated limes, when made into mortar and used for finishing, caused cracking of the wall and what is technically known as "blowing," owing to the fact that when lime slakes it expands and that this unhydrated lime slaked after being applied to the wall and after the plaster had hardened, causing a change in volume of the plaster. Most of these hydrated limes soon became known as fertilizer limes, because found most suitable for this purpose, as being in the form of a coarse powder they could be readily applied to the field by means of a wheat driller. The analyses below show the character of some of these limes.

	No. 1.	No. 2.
Calcium hydrate	69.10	53.96
Calcium carbonate	13.62	31.13
Calcium sulphate	n. d	1.58
Magnesium hydrate	4.24	3.26
Silica	9.84	7.88
Iron oxide and alumina	3.02	2.34
Fineness passing No. 200 sieve	41.5%	49.0%
Fineness passing No. 100 sieve	58.0	59.0
Fineness passing No. 20 sieve	78.0	59.0

Recently several processes have been devised for mechanically slaking lime, so that it can be placed upon the market in a dry powder, and by which the slaking is done sufficiently well to allow of the use of the product in plastering, for the manufacture of sand-lime brick, in Portland cement mortar, etc.

The chemical composition of hydrated lime of course depends entirely upon the composition of the lime from which it is made. High calcium limes slake much more quickly than do high magnesium limes and it is more difficult to make hydrated lime from such quick limes owing to the fact that it is hard to mix properly the lime and water in the short time allowed. In slaking high calcium limes, a great deal of heat is developed and this tends to drive off the water before it has a chance to combine with the lime. The heat also tends to scorch the lime or change it from an amorphous to a crystalline powder, which latter form does not seem to work as smoothly under the trowel as the former. The same change also seems to occur when the water is added in two stages. Limes which contain a large percentage of silicious and argillaceous matter also slake much more slowly than do pure limes. Generally speaking, only pure limes should be used for hydrated lime. Both magnesium limes and high calcium limes may be hydrated to advantage, and the uses of the two hydrates are identical with the uses of the two varieties of lime respectively. Below will be found the analyses of some American hydrated limes.

ANALYSES OF HYDRATED LIMES.

	No. 1.	No. 2.	No. 3.	No. 4.
Calcium hydrate	90.11	83.13	56.26	45.10
Calcium oxide	none	1.87	.....	.....
Calcium carbonate	2.25	10.32	7.12	20.04
Magnesium hydrate	1.39	.....	2.17	8.07
Magnesium oxide	....	1.27	31.45	25.02
Silica	2.05	0.46	1.49	0.34
Oxide of iron & of alumina	1.01	0.44	0.73	0.18
Moisture (hygroscopic)	3.10	2.56	0.90	0.73

Manufacture of Hydrated Lime.

Lime which is to be hydrated need not be burned so thoroughly as lime which is to be placed on the market in bulk. Where lime is transported in lumps it is found necessary to partially vitrify the outside of these latter to prevent their falling to pieces in the cars. Where lime is to be hydrated, however, this is unnecessary and the softer it is burned the better, provided that the larger portion of the limestone is converted to the oxide. This may be effected at a temperature of less than 1,000° C. Where lime is to be hydrated, therefore, slow burning kilns should be employed.

Processes for the manufacture of hydrated lime practically all consist of three stages: (1) the crushing of the lime; (2) the mixing of the lime and the water, and (3) the separation of the hydrate from the unhydrated portion, or else the grinding of the latter.

The hydrating plant itself is usually located immediately adjacent to the lime kilns. The lime is drawn from the kilns and, without allowing it to air-slake or to cool further than is necessary to prevent its setting fire to the belts which are used to convey it, is dumped either directly into the crusher or else on to a belt which discharges into the latter. Where only a few kilns are employed, the crusher may be located at a central spot convenient to all, but where there are six or more kilns a belt conveyor running along in front of the kilns and below the cooling floor will be found most economical. The lime should be discharged on to the belt through openings in the floor which when not in use are to be covered. The crusher should be located with its top flush with the floor. To prevent careless workmen falling into it, a coarse grid made of iron bars about 8 ins. apart should be made to fit the opening and fastened to this latter so that it may be easily removed for repairs.

The crusher usually employed consists of some form of rotary or "pot" crusher. Gyratory and jaw crushers are never used, as they clog up with such soft material. The Sturtevant "open-door" crusher is probably used at more plants than any other form. These crushers reduce the lime to such a size that it will all pass a ½-in. ring screen. This is as fine as it is necessary to reduce it for either the Kritzer or the Clyde hydrator. With some other forms of hydrators, however, the lime is actually ground before being fed to the hydrator. This may be done by any form of grinding mill and it sometimes carried so far as to make the product pass the 20-mesh screen. The sizes of rotary crusher usually employed are the Nos. 1½ and 2 Sturt-

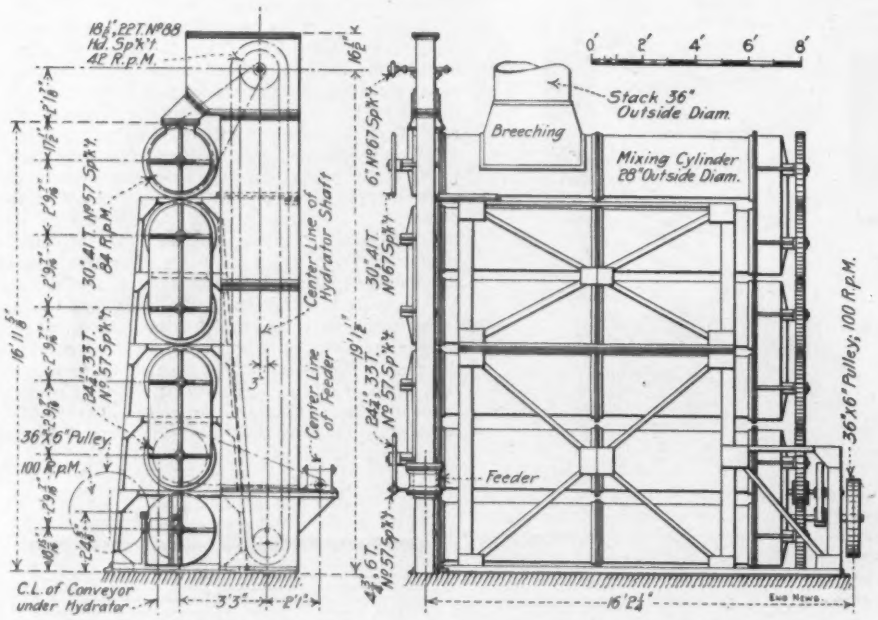


FIG. 1. DETAILS OF KRITZER HYDRATOR FOR HYDRATING LIME.

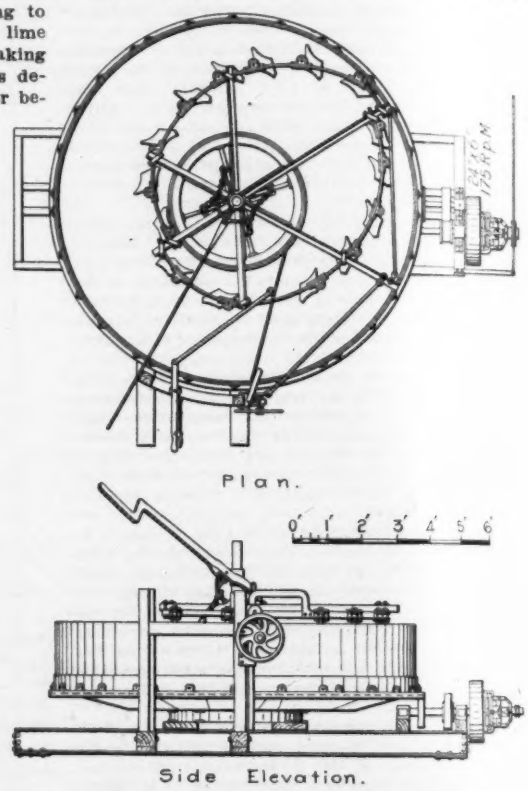


FIG. 2. DETAILS OF CLYDE HYDRATOR.

*Consulting Chemical Engineer, Allentown, Pa.

vant. The smaller of these will easily take care of 60 to 75 tons of lime per 10-hr. day.

The crushed lime is transported from the crusher to the hydrator on a belt conveyor. This usually discharges into the foot of a bucket elevator which lifts the material into a large bin above the hydrator. This bin should be of steel or other non-inflammable material as the quick lime might set fire to wood. Sometimes wooden bins lined with asbestos board and metal sheets over this are used, but the steel bins are better and almost as cheap as these latter.

Mechanical Hydrators.

All hydrators may be divided into two classes, (1) continuous hydrators and (2) batch hydrators.

Only one form of continuous hydrator is used to any extent at the present time. This is the Kritzer hydrator (Figs. 1 and 3). This hydrator consists of a number of horizontally-mounted cylinders about 12 ft. long and 20-30 ins. in diameter, mounted on a steel frame work, one above the other. These cylinders are from four to six in number and the lower ones are larger in diameter than the upper ones. Each cylinder is provided lengthwise with a central shaft to which are fastened a number of paddles. These paddles are actuated by means of gearing at one end. The cylinders are closed at both ends with an opening on the lower side of one end and the upper side of the other end, and are placed with the lower opening opposite the upper opening of the cylinder beneath it so that the cylinders discharge one into the other. The lime is fed into the upper cylinder in a continuous stream and here water is sprayed upon it, the amount being regulated by a needle valve. The moist lime is worked by the paddles and passed through the upper cylinder to the next lower one and so on down until it eventually works its way through the bottom cylinder and out of the hydrator. When discharged from this latter, the hydration is complete and the hydrated portion of the lime is in the form of a dry fluffy powder.

Considerable heat is, of course, developed in the process, the temperature of the top cylinder being from 80° to 90° C. This unquestionably helps to hydrate the lime quickly, otherwise much of it would remain unslaked. The steam which is generated passes from the lower cylinders up through the upper ones and also helps to hydrate the lime. Ventilation is necessary, and this is provided by means of a tall stack connected with the upper cylinder. Considerable dust is formed in the hydrating. This if allowed to pass out of the stack would cause considerable nuisance in the neighborhood. To prevent this there are located in the stack a water jet and a number of cones over which the water passes. This device serves to collect this dust, while the water uniting with the latter forms milk of lime which is allowed to enter the hydrator. Indeed, now all the water used for hydration is introduced into the stack.

The amount of water fed to the hydrator is controlled by a needle valve provided with a pointer and dial and is supplied by a pump. The pump is run by means of a chain from the hydrator and when the latter stops, the pump stops, thus preventing the flooding of the hydrator by a careless operator. The lime is fed into the upper cylinder of the hydrator in a steady stream by means of a mechanical feeder, and by regulating the valve the attendant can add the proper amount of water to slake the lime. If too much water is added, the hydrated lime will leave the hydrator wet and will not screen properly. If too little water is used, the lime will be unhydrated and this may be detected by the fact that it heats up when more water is added. An opening, closed by a slide, is provided in one of the top cylinders for drawing samples. The operations of the top cylinder can also be watched through openings covered by slides in the top of the top cylinder. The operator requires some practice to properly manipulate the hydrator, but any intelligent workman can be taught in a few weeks' time how to run the machine and turn out a good product.

The capacity of a hydrator depends largely upon the kind of lime hydrated, how hard the lime is burned, how much silica it contains, etc. A six-cylinder Kritzer hydrator should hydrate from 4 to 5 tons of high calcium lime per hour, and slightly more than this amount of magnesium lime, which hydrates more easily.

The Clyde hydrator (Fig. 2) is a "batch" machine in which the amount of lime and water are weighed in separate charges. The hydrator itself consists of a steel pan 10 ft. 6 ins. in diameter and 20 ins. high resting on a ball bearing. This pan is revolved by means of a gear and pinion located on the under side, and is provided with a hood top and a stack. This top does not revolve. In the center of the pan is a circular opening which is closed by a metal rim. This rim is raised when the lime is to be discharged. Suspended from a stationary framework above the pan are a number of plows which reach to the bottom of the pan. The lime and water are accurately weighed. The lime is introduced into the pan through an opening in the side of the hood and the water is spread upon the latter by means of a sprinkler pipe running across the pan, during which time the pan is revolved. As the pan revolves, the plows turn the lime over and over, thoroughly mixing the lime with the water. The heat generated in the process evaporates all of the free moisture, leaving the product dry and at a temperature of about 200° F. When the operator deems that the hydration is complete, which he determines by drawing a sample, the central rim is raised. This exposes the opening in the center of the pan. An automatic scraper attached to the framework is now lowered and the pan revolved. This scraper forces the lime to the center of the pan and consequently through the opening in the latter. It falls from the opening into a steel hopper and is conveyed from this to the screens by means of a bucket elevator or other conveying device.

The plows are arranged in the form of an ellipse (with one of its axes about the center of the pan) so that they completely cover the whole surface of the pan. The plows on one side of the ellipse are right hand and on the other left so as to work the lime thoroughly.

The lime is usually weighed in batches of 1,500 to 2,000 lbs., and the process requires from 10 to 15 minutes from the time the lime is dumped into the hydrator until it is emptied and ready for another charge, so that the capacity of the hydrator is from about 4 to 6 tons of lime per hour.

The best arrangement of a plant for this hydrating system is to locate the receiving bin for the quick lime in the roof, then below this the scales, which should be of the hopper type and controlled by a lever, and below the scales, the hydrator. The hydrator should dump into a pit or onto a belt and the lime elevated thence up to the small bin above the screens. These latter should be located above the packing machine bin.

A number of other hydrators are in use. These consist for the most part of closed cylindrical drums into which the lime is introduced through an opening in the side, which is then closed. Water is introduced by means of a pipe running through a hollow shaft which supports one end of the drum. The drums are revolved while the water is being added and for some time afterwards. In some forms of drum hydrator, steam is introduced in place of water, and in one system of hydrating two drums are used, in one of which water is employed to partially hydrate and in the other steam to complete the hydration. A hydrator consisting of an inclined rotary cylinder is also employed, in which the lime and water are fed in continuously at the upper end while the cylinder revolves. The lime and water are mixed together by the revolving of the cylinder and the mixture gradually works its way down through the cylinder and out at the lower end, when hydration is completed. In still another system an excess of water is used, which is evaporated in dryers by means of the waste heat from the lime kilns.

Practically all of these latter systems are used at but one plant, usually that of the inventor. The drum hydrators give an excellent product and, when steam is used, one which is thoroughly hydrated and consequently well suited for the most exacting class of work. They are, however, much less economical of operation as far as costs go, than the Clyde and Kritzer systems.

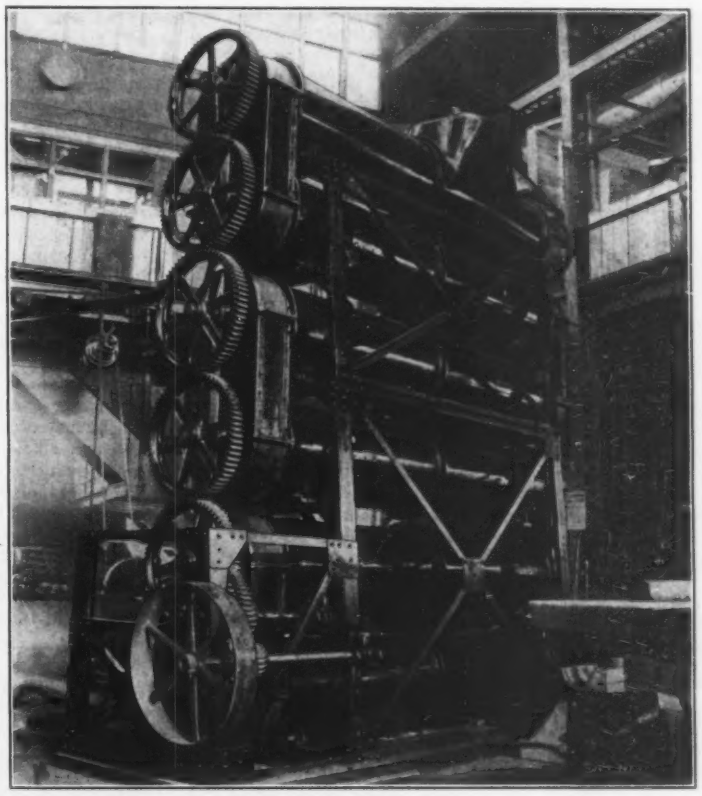


FIG. 3. VIEW OF A KRITZER HYDRATOR SET UP IN SHOP.

They all require screening or grinding of the product if this latter is to be fine.

A hydrator which is much used abroad is that of Schutless. This is a French machine and consists of a long horizontally placed cylinder, in which is placed a revolving screen. The lime and water are fed into this screen through a hopper. The lime, of course, in hydrating falls to a powder and passes through the meshes of the screen to the bottom of the cylinder and the cores remain inside and gradually work their way to the end of the screen. This hydrator is an entire plant of itself and requires no crushing of the lime nor sieving of the product. It is well suited to small capacities, therefore, but, unfortunately, has never been tried out in this country.

Screening.

After passing through the hydrator, that portion of the lime which has been slaked is in the form of a very fluffy powder, all of which will pass through a very fine sieve. The total product as it comes from the hydrator, however, always contains lumps or cores. These consist of three things: first, unslaked lime; second, unburned limestone, and third, silicious matter in the limestone. If the lime has been burned very

hard, there will be a considerable amount of core consisting of unslaked lime. If the lime has not been burned very hard, the cores will consist of unburned limestone, while with impure limestones the cores will consist largely of silicious matter. Where the lime has been normally burned, it usually consists of all three. Below will be found the analysis of the cores or screenings from a high calcium hydrate.

ANALYSIS OF CORES FROM HYDRATED LIME.

Silica	28.10%
Iron oxide and alumina	3.06
Calcium oxide	16.16
Calcium carbonate	42.12
Calcium hydrate	8.10
Magnesium carbonate	1.26

For the better grades of hydrate, it is usual to separate out this core by means of screens. These may be of several patterns, among those most employed are the Columbian screen, the Newaygo separator, both of which are inclined and employ screens, and the air separator. In Europe the air separator is chiefly used, but in this country the screen is more popular.

The two forms of screens most used in this country for screening hydrated lime are the Newaygo separator and the Columbian separator. Both of these consist of an inclined screen mounted at an angle of about 45°. In the case of the Newaygo separator the screening device consists of two sets of wire cloth screens, one, the upper, of coarse mesh which serves as a scalper to take off the large pieces and protect the lower screen, and one, the lower, of finer mesh which serves as the final separator. On

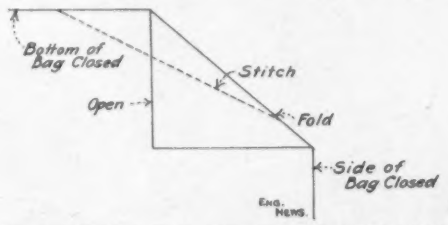


Fig. 4. Sketch Showing Construction of Bates Valve Bag.

this fine mesh screen are mounted steel bands running from the top to the bottom. Short steel bars rest upon these bands. A shaft actuated by power runs across the top of this screen and on this shaft are hinged short pieces of iron to form hammers. When the shaft turns, these hammers strike the steel bars resting on the fine screen and the jar serves to bounce the fine material through and keeps the screen from clogging.

With the Columbian separator in place of bouncing the screen, this is made to oscillate back and forth. This motion is produced by means of an eccentric and toggles. With both forms of screen, the material to be separated is fed in at the top of the screen by means of a screw conveyor, which can be adjusted so as to feed the material uniformly along the width of the screen. The coarse material, of course, rolls over the screen and the fine passes through. Both screens are encased so as to prevent unnecessary dust in the mill, but in spite of this when used for hydrated lime it is usually found necessary to box them up. The fineness is regulated by the inclination of the screen and also by the wire cloth used, which is always much coarser than the product—for instance, the 30-mesh screen is usually used for hydrated lime, practically all of which will pass the 100-mesh sieve. These screens require very little power to operate, one to two horsepower being sufficient.

Air separators are employed in place of screens at a number of works in Germany and France. Among these may be mentioned the celebrated La Farge works, at Le Teil, France. The Pfeiffer separator* is one of the best known types of this appliance. It consists of an outer and an inner cone of sheet metal, as shown in the sketch. The material to be separated is fed in at the top through a hopper, as indicated by the arrow, onto a plate which is connected to a vertical shaft and is revolved at a speed of about 150 to 200 r. p. m. The material is thrown off the plate in a thin spray by centrifugal force and is met by a current of air going in the direction shown by the arrows. The coarse particles fall through this current into the inner case and the finer ones are carried over into the outer space between the inner and outer cones. The air currents are induced by fans attached to the central shaft.

There has been some disposition of late to replace the screen by pulverizing mills; the object being to utilize the tailings and so increase the output of the plant. When this is done the entire product of the hydrator is passed to the pulverizer. The hydrated portion is, of course, already sufficiently fine and the mill is only required to grind the cores or what would ordinarily be the tailings from the screens. If these tailings consist of unburned limestone and silicious cores only, the grinding of these, of course, merely serves to increase the impurities in the lime and in no way injures it for building purposes. Indeed, in some instances, these cores consist of silicious lime compounds with hydraulic value and grinding them in actually improves the lime. At one plant where the lime contains from 10-20% finely divided silica it was found that when these cores were ground in with the hydrated lime, the product had decided hydraulic properties.

Similarly when these cores consist as they sometimes do very largely of unslaked lime, no objection need be felt to their use for most purposes as the finely ground lime will usually hydrate comparatively quickly; promptly enough at any rate for the use of the lime for mortar purposes. Where the lime, however, is to be used for sand-lime brick, it must contain practically no unhydrated lime and for this purpose the screens give much the better product. The screens, however, are troublesome and when they can be dispensed with this had better be done.

Where the screens are not used the lime passes from the hydrator to the grinding mill, where it is usually ground so fine that at least 80 to 90% of it will pass the 200-mesh sieve. Usually a much finer product is obtained with the screens that without them, although any one of the mills mentioned below may be set to give a product fully as fine as the screens. An ideal installation would consist of a set of screens followed by some form of grinding mill to take care of the cores. The lime passing the screens should be used for the manufacture of sand-lime brick, for finishing work, etc., while the cores are ground finely, mixed with a certain percentage of hydrated lime, which may or may not be made to pass the screens, and used for mortar work and fertilizer purposes.

The mills usually employed for grinding either the tailings only or the entire product are the Fuller-Lehigh mill and the Raymond mill.* Where the former of these mills is employed, only two of the four balls are needed. With both of these mills the separating is done by air.

The Fuller-Lehigh mill consists of a chilled iron horizontal die against which four balls are caused to revolve by means of pushers, the balls being forced out against the die by centrifugal force, and it is between the balls and the die that the lime is ground. The fine material is sucked up by means of fans and blown out through screens which are used merely to control the draft.

The Raymond mill consists of a horizontal ring or die against which are made to revolve four rolls suspended by a shaft from a revolving framework. The fine ground material is sucked out by means of a blower and allowed to settle in a cone-shaped reservoir.

Packing Hydrated Lime.

Practically all hydrated lime is packed by means of the Urschel-Bates automatic sacking machines. These allow it to be packed very rapidly and, with respect to the weight, accurately and with a minimum of dust. This system is the invention of Mr. A. M. Bates. It was first used for hydrated lime at the plant of the Woodville White Lime Co., in Ohio. This system primarily depends upon a novel bag, of which the fundamental feature is a valve in one corner. This valve projects into the bag, as shown in Fig. 4. It is made by ripping and tearing down a corner of the bag and sewing up on the dotted line shown in the illustration. When pressure is applied to the valve from the inside, as is the case when the bag is filled and reversed and the lime comes against it, the valve closes.

With this bag, the operation of filling, which ordinarily consists of putting the material in the bag and then tying it, is reversed and instead the bag is first tied and then filled, the filling being done through the valve by means of the special bagging machine described below. When paper sacks are used, these are closed at both ends in the bag factory, where the valve is also placed in the bag by folding and pasting. The cloth bags are tied at the lime plant on a special machine which is capable of handling 25 bags at once. With this appliance a boy can tie between four and five thousand bags in a day of ten hours.

To fill the bag the operator has only to throw the self-closing valve of the finished bag over the tube of the bagging machine. This he does with a quick one-hand motion. A lever is then opened which permits the material to flow into the bag in a thin stream about 1 in. in diameter. When the exact quantity of lime desired has been fed into the sack, the weight of the bag and contents offsets a counterpoise at the opposite end of an evenly balanced beam, the bag, of course, begins to fall and simultaneously with this the flow of material is shut off. The bag has only to move ⅛-in. for this to take place. When the bag has been filled it is tilted down to the truck and wheeled into storage or to the cars.

Hydrated lime is usually packed in paper bags holding 40 lbs. to the bag, or else in burlap sacks or cotton sacks holding 100 lbs. each. Paper bags are not returnable, but the cotton and burlap ones are.

Cost of Plant and Hydrator.

A plant consisting of one Clyde hydrator and the necessary screening, packing and conveying machinery, for the hydration of magnesian limes having a capacity of two or three tons per hour can be equipped for about $6,000. This does not include buildings, which if of frame would probably add $1,500 or $2,000 to this. A plant of double this capacity and containing two hydrators could be built for about $8,000, exclusive of buildings. The first plant would require about 30 HP. and from three to five men, while the second plant would employ from four to six men and require from 40 to 50 HP. The equipment of a plant for the hydration of high calcium lime by the Kritzer process, having a capacity of from three to five tons per hour, would cost $12,000 to $15,000, to which must be added the cost of the buildings. From four to five men would be required for the operation of the plant and about 50 HP. would be needed.

As to the cost of hydrating lime, manufacturers commonly calculate that the cost of hydrating lime is borne by the increase in product. For instance in hydrating a ton of pure high calcium lime (2,000 lbs.) there will be obtained 2,600 lbs. of hydrated lime, taking into consideration the cores. The quantity of hydrated lime which will actually be obtained, however, depends, of course, upon the amount and treatment of the tailings. If these latter are ground up, a ton of lime will produce from 2,400 to 2,600 lbs. of hydrated lime. Where the hydrate is sieved, however, a ton of lime will seldom produce more than a ton of hydrated lime. Fig. 5. gives the general details of a typical medium size plant.

Below is a statement of the cost of hydrating lime, where the tailings are ground in with the lime.

COST OF HYDRATING 30 TONS LIME.

1 Engineer and fireman combined	$2.00 — $2.50
1 Hydrator and mill attendant	2.50 — 3.00
1 Man at crusher at $1.40 to $1.75	1.40 — 1.75
2 Men at packer at $1.60 to $2	3.20 — 4.00
Power, lubricants, etc.	1.50 — 2.00
Cost of hydrating 30 tons	$10.60 — $13.25
Hydrate produced (tailings included)	40 tons
Cost per ton	$0.265—$0.331

*Fully described in Engineering News, Feb. 16, 1911, p. 191.

*Both of these mills have been described in Engineering News, June 21, 1906, p. 686.

Uses of Hydrated Lime.

The uses of hydrated lime are for the most part those of lime itself. In addition to this it can be used in some ways in which quick lime cannot be employed and also it has certain advantages which make it easier for both the manufacturer and the dealer to handle than quick lime.

First, it is a fixed product which does not deteriorate or change with age, consequently it may be conveniently stored at either the plant or in the dealer's warehouse. This cannot be done with quick lime, which will rapidly air slake and change to the carbonate, when the attempt is made to keep quick lime any length of time. This carbonate is worthless, of course, for most purposes for which lime is used. Hydrated lime is consequently always worth the market price of this product, while quick lime is continually decreasing in value.

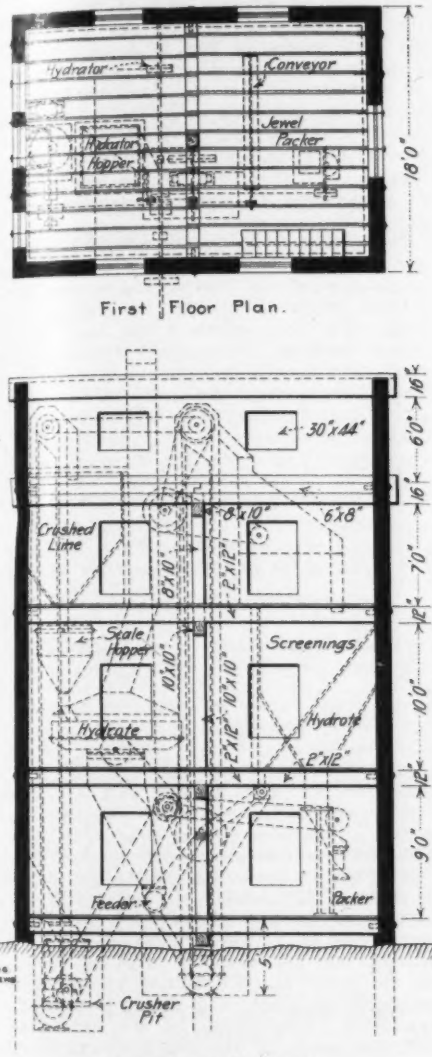


FIG. 5. LAYOUT OF LIME HYDRATING PLANT OF THE CARBONIC DIOXIDE CORPORATION, DULUTH, MINN.

The stability of hydrated lime allows it to be handled without risk of fire. Many warehouses have been burned by water getting to the lime with the result that the heat developed by the slaking set fire to any woodwork in contact with the pile. Hydrated lime may be shipped by water without risk of fire and it is usually accepted by steam packet lines for water transportation. This they will not do with ordinary lime.

One of the great advantages of hydrated lime is the ease with which it can be packed. Quick lime, of course, cannot be shipped in either cloth or paper bags, but when shipped in small lots must be packed in barrels. If left in these latter any length of time, the lime usually slakes to some extent and swells, causing the bursting of the barrels. There is also the danger of fire with lime packed in barrels, which always occurs where lime is kept in contact with wood. A great deal of lime is shipped, of course, in bulk in box cars. This must always be disposed of promptly by the dealer in order to prevent slaking and deterioration of the lime. With hydrated lime, on the other hand, the fact that it may be packed in cloth and paper bags makes it very easy for both the dealer and the manufacturer to handle. If packed in cloth bags, these are usually returnable at from 75% of their full value to the latter. Where the paper is used this costs from 90 cts. to $1.10 per ton for package. With barrels, on the other hand, these can seldom be made for less than 25 cts. for a 200-lb. barrel, which makes the cost of package for a ton of lime in wood about $2.50. Often it is much more than this, as of late there has been a steady rise in the price of cooperage stock and consequently of barrels.

Hydrated lime is very much more convenient of application than quick lime. It does not have to be slaked in the mortar box. Consequently it is particularly useful for small jobs and for patch work, for laying bricks, etc.

It has long been known that additions of slaked lime improved in a great many ways cement mortars, notably the troweling and waterproofing properties of these latter. It is, of course, practically an impossibility to mix lime putty with cement, sand and gravel economically. Hydrated lime on the other hand may be very conveniently mixed. It is usually employed in proportions of about 15 parts lime to 85 parts cement or, in other words, 15% of the cement is replaced by lime. That is for each bag of cement 17 lbs. of hydrated lime are used, and this mixture will make as much concrete as 1.2 bags of cement. It is probable that hydrated lime is the best waterproofing compound that we know of. It is of mineral origin and, in the proportions named above, does not effect the strength of concrete; whereas, all other waterproofing compounds which the writer has examined decrease the strength of the concrete from 5 to 20%. It is also about the cheapest waterproofing compound which can be used, as it can be bought for about the same price as cement and replaces the latter. Mixtures of hydrated lime and cement are excellent for laying brick. They harden very much more quickly than lime alone and are permanent and strong.

Many chemical manufacturers are large users of hydrated lime. It is used almost exclusively for the manufacture of bleaching powder. Several glass manufacturers have also stated to the writer that they prefer it to quick lime in their plants. A number of experts on water softening are also recommending it for use, as it is much easier of application in water softening and purification plants than is the quick lime and keeps much better.

Owing to the fineness to which hydrated lime is reduced, it is considered one of the best forms of lime for agricultural purposes, as it may be easily distributed over the ground by means of a wheat drill. Farmers generally seem to be willing to pay the increased price necessary to get it, because of the ease with which it may be applied.

Tests and Specifications.

The principal tests applied to hydrated lime, at the present time, are a sieve test to determine its fineness and a pat test to ascertain the thoroughness of the hydration. The sieves employed are the No. 100 and the No. 200 standard cement test sieves. A good hydrated lime should show a residue of not more than 10% on the 100-mesh sieve nor more than 20% on the 200-mesh sieve.

The test to determine hydration is usually made in the following manner: 50 to 100 grams of hydrated lime are mixed with sufficient water to form a rather stiff plasterer's mortar. This is then molded on a small glass plate into a pat similar to the test pieces employed for the boiling test of cement. This pat is immediately placed on a rack above boiling water in a loosely covered vessel and examined after a few hours. If no cracks or blisters appear, the hydration may be considered perfect and no fear of cracks or blistering need be felt when the lime is used for plastering. Hydrated lime pats will still be soft after this treatment and will not become hard as cement pats do, but they should not be full of small cracks nor should the surface blister.

The test is in every way similar to the steam test employed for determining the soundness of cement, except that the pat is placed in steam *immediately* after being made instead of being allowed 24 hours to harden as in the case of cement. If the lime pat were allowed this time, the free lime would have a chance to slake and no blistering would occur when the steam test was applied, except with very poorly hydrated lime.

Chemical analysis is also of use in valuing hydrated lime, as showing its nature, whether high calcium or magnesian, and also the impurities it contains. Chief of these latter are carbon dioxide, silica, iron oxide and alumina. When hydrated lime is to be used for boiler water purification or chemical purposes, it should be low in magnesia. Some engineers also prefer low magnesia hydrated lime for waterproofing concrete, fearing the influence of magnesia on Portland cement. This, however, is a disputed point. For finishing and mortar purposes, magnesian hydrates are extensively employed. Generally speaking, for all purposes, silica, oxide of iron, alumina, and carbon dioxide should be low. The writer suggests the following specifications:

SPECIFICATIONS FOR HYDRATED LIME.

FINENESS.—Residue on the 100-mesh sieve, less than 10%. Residue on the 200-mesh sieve less than 20%.
SOUNDNESS.—Should pass perfectly without showing blisters or cracks the steam test outlined above.
CHEMICAL ANALYSIS, FOR HIGH CALCIUM LIMES.—Less than 6% silica, oxide of iron, alumina, carbon dioxide and magnesia.
FOR MANGESIAN LIMES.—Less than 5%, silica, oxide of iron, alumina and carbon dioxide. Magnesia not less than 30%.

These specifications can be filled by most of the hydrates at the present time on the American market and are sufficiently rigid to exclude an inferior article or one not adapted to plastering, waterproofing concrete and general mortar purposes.

A New Design of Blower for Increased Efficiency.

By A. H. ANDERSON.*

The purpose of this article is to describe a new construction for air blowers which gives better results than the older established designs. A simple centrifugal blower with six radial vanes has an efficiency of about 40%. A later type, having a large number of narrow vanes, has an efficiency of about 60%. The proposed design has shown under test an efficiency of 77.7%.

It is necessary, in outlining the theory of the new design, to refer first of all to certain experimental investigations which have

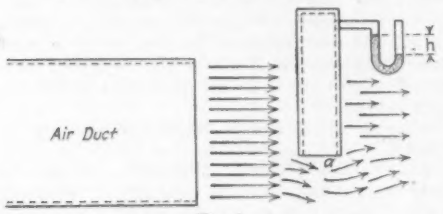


Fig. 1.

been made. If we introduce one end of a tube in a stream of air, as shown diagrammatically in Fig. 1, and if we connect the other end to a U-tube containing water, there will be indicated, in the U-tube, a suction which we may call h. Comparison of the suction h with the head corresponding to the velocity of the air current reveals the remarkable fact that they are identical. The introduction of the tube into the current of air causes a temporary diversion of the stream lines and leaves a space a under a negative pressure which is, of course, communicated to the interior of the tube. Suppose the air particles to have a velocity V feet per second; then the head represented by that velocity is $\frac{V^2}{2g}$ and experiment shows that a negative pressure of exactly $\frac{V^2}{2g}$ is formed in a. The same suction h will be formed in the tube if it is moved in a straight line through still air. Now, arrange the tube so that one end may be rotated about the other end as a center and by means of a suitable stuffing box connect a U-tube with the interior of the tube. Let the linear velocity of the rotating end be V, and it will be found that the suction indicated in the U-tube is exactly equal to $\frac{V^2}{g}$. The additional suction of $\frac{V^2}{2g}$ is caused by centrifugal force.

The rotating end of the tube has had its plane at right angles to the axis up to now and it is next desired to show the effect of varying this angle. Let the end of the stationary tube immersed in the current of air be cut down to make an angle of 10° with a perpendicular to the rear element of the tube, as in Fig. 2. The suction will

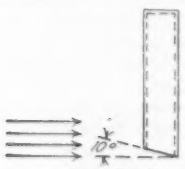


Fig. 2.

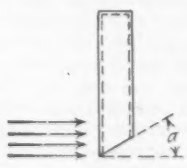


Fig. 3.

be less than h, and if the tube be rotated in still air about the upper end of the longest element, as a center, so that air will strike the inclined area of the end, then the U-tube will indicate a suction of less than $\frac{V^2}{2g}$, V being the velocity of the tip. It is found that the reduction of suction in this case is exactly equal to the reduction of h in the case of the stationary tube. This indicates that the centrifugal head is not affected by the change of the angle, but that the impact head is. Let the angle be increased to 20° and the suction head of the stationary tube is still smaller than with 10°. When the tube is rotated the suction head is less than $\frac{V^2}{g}$. Increase the angle to 30° and the stationary tube shows neither suction nor positive head and, when rotated, the suction indicated on the U-tube is exactly $\frac{V^2}{2g}$, the value of the centrifugal force. With the angle of 30° the impact head is entirely neutralized and the construction is such that only one-half of the possible head is utilized. If the angle is increased beyond 30° it is found with the stationary tube, that a positive head is shown in the manometer, and that the suction of the rotated tube is further decreased by a like amount.

Now, let the tube be turned as in Fig. 3, and it is found that, no matter what the angle a may be, the suction remains the same. If the tube be rotated, about the upper end of the longest element as a center, the suction is always $\frac{V^2}{g}$.

The foregoing shows the maximum effect is obtained when the plane of the rotating tip is at right angles to the axis, or inclined to any angle away from the direction of rotation as in Fig. 3. Suppose a number of tubes radiating from a common axle and we have a blower whose manometric efficiency is 100% the suction produced being $\frac{V^2}{g}$. If an opening is made in the axle so that air may be drawn through it and discharged, a part of the suction head $\frac{V^2}{g}$ is used in moving the air but the probability is that the mechanical efficiency would be very high.

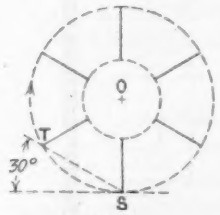


Fig. 4.

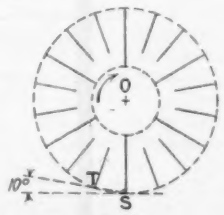


Fig. 5.

Compare the above ideal construction with the usual construction of a six-bladed blower Fig. 4. The channel contained between two adjacent vanes corresponds to the experimental tube. Consider a single channel O S T, rotating in the direction indicated by arrow. The line T S, equivalent to the top of the experimental tube, shown in Fig. 2, makes an angle of 30° with a perpendicular to the rear element. Following the experience with the experimental tubes, the suction expected would be only $\frac{V^2}{2g}$ or one-half the maximum possible with a different design which would utilize impact head. This six-bladed blower could not exceed 50% efficiency.

Next consider an 18-bladed blower, as in Fig. 5. The angle between the end of one channel and a perpendicular to the rear element is 10° and the suction will be greater than $\frac{V^2}{2g}$, but less than $\frac{V^2}{g}$. A 36-bladed blower, Fig. 6, will have an end angle of 5°, still further increasing the suction. With each increase in the number of blades there is an increase in efficiency, but evidently 100% efficiency is unattainable for that would mean an infinite number of blades. Furthermore, with each increase in number of blades there is an increase in the surfaces over which the air must move which causes considerable increase in loss in friction. The frictional resistance is so great that the gain in mechanical efficiency, by increasing the number of blades indefinitely, is quite small. The makers of one type of multi-blade blower claim a mechanical efficiency of some 60%, which is only a small gain over the older types. In an endeavor to avoid the excessive air friction of the multi-blade fan the type shown in Fig. 7, has been built and tested. This is nothing more than six tubes radiating more or less tangentially to the edge of the intake opening. This gives a design with the rear element of the tube at right angles to the end of the channel which inclined away from the path travelled. Fig. 8 shows the actual construction of a runner as constructed to reduce the amount of dead air space over the diagrammatic layout of Fig. 7.

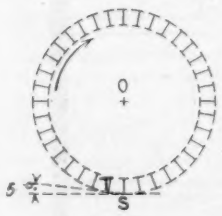


Fig. 6.

Fig. 7.

The mechanical efficiency found by test was 77.5, being an advance of more than 15% over the old multi-blade blower, and 30% over the old style shown in Fig. 5. Another important gain should be noted. The blower in Fig. 5 is characterized by the fact that the input horsepower increases with the cube of the speed, which is also true of the multi-blade blower as given by the catalogues of the makers. As the speed of the blower in Fig. 8 is increased the input horsepower goes up almost by the square.

The method of testing the runners is shown in Fig. 9. The runner is here encased, being mounted overhung, leaving the suction opening entirely on one side. The bearings were babbited, each being about 4 ins. long, with the pulley between. The runner was driven by a 110-volt, direct-current, variable-speed motor of the interpole type, connected to the blower pulley by a 5-in. double leather belt. The suction pipe and inlet to runner were 12 ins. diameter. The discharge pipe was also 12 ins. diameter. The volume of air moved was determined with the Pitot tube indicated in the discharge which was placed at a distance of 4.8 ins. above the center. Experiment has shown that mean velocity occurs at a distance of 0.8 of the radius from the center. The U-tube connected to the Pitot tube indicated velocity head plus static head in inches of water, while another U-tube applied to an opening in the wall of the discharge pipe indicated static head. The difference of these U-tube readings was the velocity head, which, multiplied by the factor 71, was reduced to velocity head in feet of air, from which the mean velocity was calculated. The density of air was taken at 0.073 lbs. per cu. ft. The total head against which the blower was working was taken as the sum of the static head, velocity head, and the suction head.

The blower operates most efficiently when the suction is throttled by placing a plate over the end with a 9-inch circular opening in it. As indicated in the accompanying table the test was run at various speeds from 555 r. p. m. to 1,575 r. p. m., the blower readings for each speed being suction head, static head, velocity plus static head, and r. p. m. To determine the input to the blower, ammeter and voltmeter readings were taken. The motor had previously been carefully calibrated so that the input to the blower was easily calculated. Great stress had been laid on the importance of a correct calibration of the motor. Columns 2, 4 and 5 show instrument readings; Column 3 was obtained by subtracting Column 4 from the Pitot tube reading. Columns 5, 6 and 7 were obtained by multiplying columns 2, 3 and 4, respectively, by 71. Column 8 is the sum of Columns 5, 6 and 7. Column 9 is thus derived from Column 6 (for 938 r. p. m.),

$$V = \sqrt{2 \times 32.2 \times 20.0} = 35.9.$$

Column 10 comes thus from Column 9,

$$\tfrac{1}{4} \times 3.1416 \times 1 \times 1 \times 35.9 = 28.2.$$

*Assistant Professor of Mechanical Engineering, Armour Institute of Technology, Chicago.

TEST OF A SPECIAL 24-IN. BLOWER.

R. P. M.	Suction head, ins. water.	Velocity head in discharge pipe; in. water.	Static head in discharge pipe; in. water.	Suction head, ft. air.	Velocity head, ft. air.	Static head, ft. air.	Total head, ft., air.	Air velocity in discharge pipe; ft. per sec.	Cu. ft. air per sec.	Lb. air per sec.	HP. from blower.	HP. into blower.	Efficiency.
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1[illegible]	0.825	0.098	0.01	58.6	6.9	.7	66.2	21.1	16.5	1.21	.145	.34	42.7%
2[illegible]	0.95	0.113	0.01	67.4	8.0	.7	76.1	22.7	17.8	1.30	.18	.37	48.7
2[illegible]	1.14	0.135	0.011	81.0	9.6	.7	91.3	24.9	19.5	1.42	.237	.48	49.4
2[illegible]	1.37	0.163	0.012	97.3	11.7	.7	109.7	27.4	21.5	1.57	.312	.56	55.8
2[illegible]	1.64	0.198	0.014	116.5	14.0	1.0	131.5	30.0	23.5	1.72	.41	.75	55.0
2[illegible]	1.94	0.234	0.015	137.5	16.7	1.0	155.2	32.7	25.7	1.88	.53	.87	61.0
2[illegible]	2.38	0.284	0.02	169.0	20.0	1.4	190.4	35.9	28.2	2.05	.71	1.12	63.4
2[illegible]	2.83	0.349	0.022	201.0	24.8	1.4	237.2	40.0	31.4	2.29	.932	1.35	69.0
1[illegible]	3.35	0.413	0.026	238.0	29.3	1.4	268.7	43.4	34.1	2.49	1.21	1.70	71.0
1[illegible]	3.9	0.48	0.03	277.0	34.1	2.1	313.2	46.8	36.7	2.68	1.53	2.02	75.8
1[illegible]	4.62	0.57	0.035	328.0	40.5	2.5	371.0	51.0	40.1	2.92	1.97	2.62	75.0
1[illegible]	5.35	0.66	0.04	380.0	46.9	2.8	429.7	54.9	43.1	3.15	2.46	3.24	75.8
1[illegible]	6.0	0.73	0.045	426.0	51.8	2.8	480.6	57.7	45.3	3.31	2.88	3.78	76.2
1[illegible]	6.55	0.81	0.049	465.0	57.5	3.5	526.0	60.8	47.7	3.48	3.33	4.30	77.7

Column 11 is from Column 10; $28.2 \times 0.073 = 2.05$.

Column 12 is from Columns 11 and 8,

$$\frac{2.05 \times 190.4}{550} = 0.71$$

and Column 14 comes from Columns 12 and 13

$$\frac{0.71}{1.12} = 0.634.$$

In Fig. 10 some of the results are plotted. It will be noted that the horsepower input does increase with the square of speed, a fact which prevents this type from overloading the motor before the maximum attainable speed is reached. Curve B shows that the proposed design may be run as high as 1,500 r. p. m. with only a small increase in horsepower input while the blower of curve A is soon overloaded. Curve C shows a wider range of maximum efficiency for the older type, but this is more than compensated for by the increased efficiency of the proposed type. The quantity of air handled in each case varies directly with the speed.

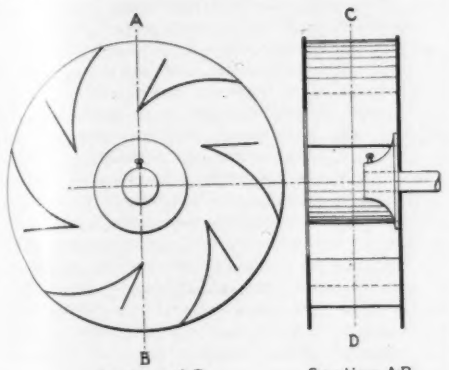


Fig. 8. New Type of Blower Runner as Actually Constructed for Experimental Runs.

Some Conditions Affecting Higher Education.*

By W. D. TAYLOR,† M. Am. Soc. C. E.

The question that should most interest every student in this school is as to how he can best use his time in the four years that he is here to acquire the training which will best fit him for success in the work he will undertake as his future calling.

And the question that should be uppermost in the mind of each teacher in this school is, not how he himself can succeed nor how much he can advance his own interest by some line of investigation that will benefit the outside world, but, how can he so conduct his work as to give to each of his students right here in this school the training that will go farthest toward fitting him for the very highest success of which he is capable. If things are ordered aright here at Purdue, it may be said to be true, in a way, that the student is here for a selfish end, and the teacher for an unselfish end. They both work for a common end—for the uplifting of the student, for the building of a man.

That was the viewpoint of the great teachers of the past, of Dr. Thomas Arnold, for instance, and of Mr. Gilman and of Dr. Elliot in later days. Just so far as the teachers of Purdue are falling short of this standard, by just so much are they failing in the duty they owe to the state and to these young men.

The colleges of our land are turning out thousands of graduates and these graduates are of three classes; good, bad and indifferent. I sometimes fear, though I am not quite sure, that the last mentioned class predominates. I have lived in this country a half century, North, West and South, and I have worked hard as youth, student, teacher and engineer. I have lived about half of my mature life as a practicing engineer and about half as a teacher.

As teacher and student I have had a somewhat intimate acquaintance with the workings of at least six of our higher institutions of learning, and I can vouch for the fact that the teachers in our colleges may also be divided into the same three classes; good, bad and indifferent; I fear that also among the teachers, though again I am not quite sure, the indifferent class predominates.

I honestly believe that, with the possible exception of the medical profession, there is more humbuggery among teachers than among the members of almost any other profession. In almost any other profession than these two, you can measure a man's efficiency by the results of his work. The patient is dead and you can't hold the doctor to account. The costly structure built by the engineer graduate tumbles down and surely, surely you would not blame his teacher! Why, what has he to do with it?

Let me specify a thing or two about inefficient teachers. I knew only too well the President of a college who was bound up tight in other business besides his teaching, and who did not give to his college any of his best efforts, although he ostensibly gave it a large part of his time. He was something of a politician; and so anxious was he to be popular that he undertook to agree with everybody who sought his direction and counsel. Under these conditions, as you may suppose, his faculty attended to their duties when they pleased; and when they didn't please they went elsewhere and did as they pleased. The buildings and grounds of the school over which that man presided were indescribably dirty and the cobwebs were thick across the windows of the faculty room of that institution. Yet that man held himself in his position for more than fifteen years and was not deposed until after a student uprising protested against his inefficiency.

I have a daughter, who is an earnest student and who was entered at one of our great institutions. She wanted to perfect herself in the studies of a certain department but she could not do so without entering the classes conducted by the head of that department. This man, though learned, was one of the teachers who easily fall into the indifferent class. He also was interested in other business, besides his teaching he was speculating in land and drainage schemes and he was selling coal. This man came late to all of his classes that he did not forget and miss altogether.

When he did come, he rarely remembered what the assigned work was; and if he essayed to lecture, he was just as apt as not to fire away on a part of the subject weeks ahead of his class or on a part over which they had passed the month previous. Yet that man held that chair for more than twenty years, until, at last, the governing board gave ear to the oft-repeated complaints against him and removed him. The removal came too late, however, to benefit my daughter as she had been driven out of her chosen work into other fields by this man's inefficiency.

These, of course, are glaring examples and are not, I am happy to say, typical of what our teachers are; but they serve to show what are the possibilities for evil under the unbusinesslike methods upon which our institutions of higher learning are conducted. How long could the President of that school have held his position as president of one of our great business corporations or railroads? And how long could the educational department head have hung on as head of one of the departments of our great railroads? In business such men are rarely appointed to responsible positions; but if a mistake is made and they are appointed, they are withdrawn before they reach the quarter post in the race.

In every great army that ever won a battle, it has been demonstrated that large bodies of men, at least of the Anglo-Saxon race, working to a common end, cannot be kept up to a state of efficiency without an executive head that directs and commands, and without an organization to inspect and report and amend the deficiencies of every officer and of every private from the smallest to the greatest.

The organization of every great successful corporation and of every great railroad company is founded upon the necessity for supervision and inspection to assure efficiency in operation. It is a sad fact that great bodies of men cannot be depended upon to work together efficiently unless they are, in a way, forced to do it. The railroad president does not depend upon the roadmaster's report to be sure that his track is safe to carry the winter's traffic. The superintendent must inspect the track and report on the roadmaster's report. The general superintendent must inspect the track and report on the superintendent's report. These must all go to the

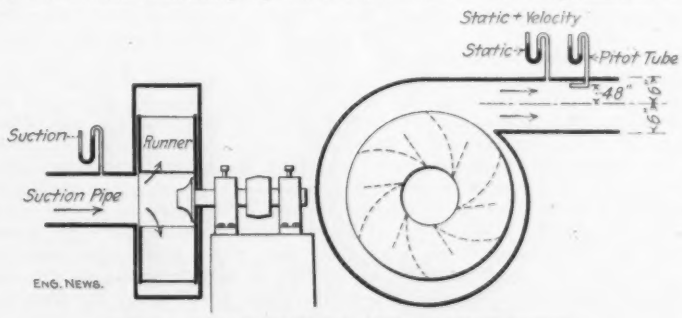


FIG. 9. ARRANGEMENTS FOR BLOWER TESTS.

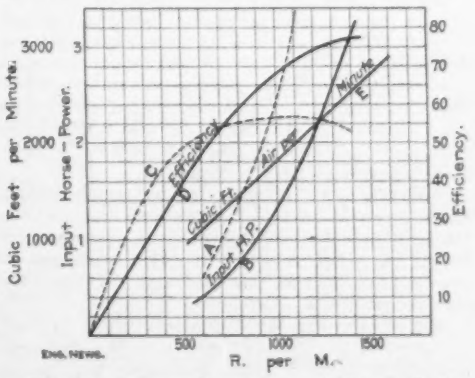


Fig. 10. Comparative Curves of Blower Tests.
(Curves A and C for old type; curves B and D for proposed design. Curve A corrected for difference in capacity of blowers.)

*An address delivered at Purdue University, Lafayette, Ind.

†Chief Engineer, Chicago & Alton R. R. Co., Chicago, Ill.

chief engineer who in turn must inspect and report, then to the general manager who must inspect and report and then in condensed form the reports all go to the president.

Checking, supervision and inspection are absolutely necessary in every calling except in teaching. Only as a teacher is a man supposed to be perfect and not to need active and insistent supervision.

Perhaps at this point you would challenge my statement to the effect that there is so much humbuggery in teaching by asking if the average man in teaching work is not at least the equal of those in other professions. And I would answer that I believe that at the start the average young teacher in our colleges is even superior to the average man in other callings. But in other callings, the average man is held to a strict accountability for his work. He must deliver the goods. In teaching, with no one to call him to a strict account, a man may oftentimes neglect his work (especially if he has written a book or developed a machine that has attracted some attention), a little at a time, and more and more, until he is as far from the true ideals of manhood—until he has betrayed his trust as completely as the Presidents of the great life insurance companies had at the time of the Hughes investigation.

Just think for a moment of the manner in which teachers are generally developed in our colleges. When a teacher is needed, some young man with certain characteristics is singled out from the current graduating class. His name is John Brown and he may have never thought seriously of becoming a teacher. The salary offered him to teach drawing or mathematics to the incoming freshmen will probably be about 70% of what he has just been offered as assistant draftsman to the erection engineer of a soap factory. Brown considers the matter for a while and finally decides for the students as against soap and so he begins to teach. When he gets down to work, no experienced teacher ever comes near him to see what he is doing with his men. If Brown is reasonably diligent at first and the students don't make a direct onslaught upon him, he easily establishes a fair name for himself, and as the school grows Brown is promoted and by the time he is 35, he occupies a chair of some sort of "ics or ology."

Probably in all this time no one has ever gotten straight behind Brown to check him up and report on his efficiency and to see that he was consecrating himself to the good of his students and to their upbuilding. And in the meantime Brown has learned that he can shirk this and neglect that and that no one will be the wiser. A few years after Brown has acquired his chair he feels settled in it and becomes assured also that there is no chance for further advancement for him in educational work. Naturally, therefore, he becomes interested in other pursuits. His school duties consume less and less of his best efforts and soon Brown is merely holding on to his professorship in order to have the school support him while he works out some outside scheme which is to make him rich.

Brown now has a regular set of lectures and a course to offer which, even as to the time and place for his standard jokes, is as unchangeable as the laws of the Medes and Persians. Brown is known to the students as "a good fellow" and his courses as "a snap" and he is popular with the students, for these poor benighted creatures, the students, seldom understand that oftentimes that teacher is their best friend who makes them work hardest. Brown has now become a first-class inefficient and a humbug.

In hardly any other profession would Brown have degenerated into the man he now is. In the beginning he probably had the qualities that could have developed him into a first-class teacher, but he was spoiled in the making. He was the victim of a system.

And what about Brown's pupils? The Browns in every faculty are well known to the students. Soon after Brown began to become lax in his duties, some bright wag of a student who had discerned this fact, slipped in a blank paper on his final examination under Brown and received the same mark as his classmates who laboriously worked out the subject matter. Thereafter Brown has a reputation and students flock to his classes. Even he cannot account for the sudden popularity of his courses, but he finally ascribes it to a recognition of his own great personality long deserved and delayed. Several Browns in a faculty enable students to do worse than waste their time, and to leave their Alma Mater without having acquired any great amount of training and without having formed a single habit that fits them for any serious purpose in life.

Thus in handling our great colleges we try to leave each teacher to follow his own bent—to work out his own salvation and that of his students. And what is the result of our system? Review the current periodicals for the last six months or a year and see what an attack is being made on the colleges of the country. I have read many charges but I have seen few defenses, and what I have seen are very lame ones.

Let me tell you what I heard the other day. I was talking with a man who occupies a high executive position with a Western railway. This man had lived for years in an Eastern city in which one of the great universities of the land is located, and several students of that university boarded at the same place in that city that he did. He said to me: "If I had a son, I would as soon think of sending him straight to hell as to think of sending him to Blank University. If there is anything you can think of that the young men at that school ought not to have, you may be sure that they are in possession of it. I have seen night after night, numbers of these young men carried to their rooms in drunken insensibility. I have listened day after day to their conversation and have heard little from them that was fit for a mother's ear. Most of what I heard was about on a par with what I have heard from cowboys in Texas and on special trains in New York State filled with gamblers going to the races. I have seen with my own eyes a crowd of these young toughs of that school link their arms over one another's shoulders and march up the streets of the city singing and yelling and sweeping old women, elegant ladies, nurses and baby carriages from the sidewalks into the street. If these young fellows were forming one single habit that would fit them for any serious purpose in life, I wasn't able to detect it."

Now this was the observation of a man who is in no wise embittered against education; one who has the greatest sympathy for his fellowmen, and particularly for young men, and whose heart is sincerely in the work of upbuilding mankind. It is true he probably came in contact with the rougher element of the students of this school and that he saw them only in their "off" hours, but even then, does it not appall you that students can indulge in such behavior as this and still remain in good standing at the first institutions in the land?

Now I will be more specific. During the last semester that I occupied the chair of Railway Engineering at the University of Wisconsin, the fall of 1905, I was appointed as one of the Faculty Committee of three on college athletics. It would be unfair to disclose to you what I learned while in that Committee concerning the moral standing of athletics in that school at that time. I had been in that school for four years previous to that time and had been sincerely striving for the good of my students; but what I learned there not only surprised but sickened me.

In my dealings with negro tracklaying gangs in the South, with railroad contractors and land sharks, I had had something to do with brutal and unprincipled men; but I have rarely met men that could vie in every attribute that was unworthy with one or two of the student representatives on their athletic committees at that time. And when I realized that these men, with all their coarseness, brutality and lack of principle, had more influence with the students than I or any other teacher, I no longer wondered that it was so difficult to break up the habit of cribbing and cheating which had such a hold on the students of that school.

I am glad to say that as a member of that Committee, I helped to formulate a report that set the Faculty to thinking and meeting and acting, which resulted in a pretty thorough cleaning up for that time at least.

My family live in a University town and for four years I have been going up and spending Sundays with them. On Sunday evenings I go to bed early and get up about 3 a. m. on Monday and walk or drive two miles through the University quarter to the railroad station to take the train for Chicago. At that hour every house I pass is dark and quiet except two, one is a bar room and the other a fraternity house. In passing I have never seen any disorder in the bar room but the conditions about the fraternity house are sometimes outrageous. Lest my words may be misunderstood, let me say that I pass several other fraternity houses that are as quiet and respectable as need be.

I could tell you much more on the same order, but I have said enough to indicate the existence of the evils against which I am directing this talk. I do not want to pass in this world as a muckraker, so let me hasten to say that I know very well that the kind of teacher and student that I have described above is not typical of the better men in our institutions. I know very well that there are noble self-sacrificing teachers and consecrated students in every great school.

But I do assert that our leading schools are not generally conducted and organized on the high moral plane that characterized our earlier institutions before college education became so popular, and I do assert that it is possible, even in this day, to so order our schools as to practically eradicate the evils I have indicated.

We have completely abolished drunkenness among the thousands of responsible railway employees of the country. Do you mean to tell me we can't do as much for the bright young men in our colleges? On our railroads we establish regulations and rules of conduct which train thousands of young men up in habits of thrift and industry which develop many of them into useful citizens and some of them into strong men of sterling integrity and of world wide fame, men like M. H. Smith, of the Louisville & Nashville, W. C. Brown, of the New York Central, and A. J. Earling, of the Chicago, Milwaukee & St. Paul.

And, mark you, when we get hold of a young man in railroad work who won't submit to training, we drop him just as we do the officer who does not attend to his duties. And that is exactly what the university and the college ought to do.

The trouble with the government of our higher schools is that there is so little of it and that what there is is principally a relic of that of the schools of long ago, which was intended to govern tender youths of from 13 to 17. In most of our higher schools, any form of government of the students has all but disappeared, whereas the good of the student requires a discipline almost as intense as that at West Point, or that about a military encampment. The wonderful success of our early colleges was due far more to their discipline and their habit-forming training than to their scholarship. And these essential elements we are now almost laying aside.

Further, we have entirely too much reverence for everything about a college. The older colleges were taught and managed almost entirely by ministers for the purpose primarily of educating young men for the ministry. That was the original mission of Harvard, Yale, Williams, Brown and Amherst. Thus there was a kind of halo around every one connected with such schools. And the schools were run usually by men of the highest integrity and of the loftiest character. But their students were nothing but boys, hardly so far advanced in studies or years as the boys who now enter our high schools. The freshmen were fagged and flogged and disciplined and were almost as completely under their teacher's sway as are small children to-day under the Sisters of Mercy in Catholic schools.

In those days the halo was deserved and real. In these days we have little of it left except the shadow. But the shadow serves to keep reform-

ing hands off of the colleges. Otherwise the methods that have wrought such benefits in our business organizations would have long ago brought about such changes in the conduct of our colleges as to make it impossible for such evils as I have indicated to exist inside their walls.

And why should not our higher schools be run on business principles? Ninety per cent. of our pupils are in our schools for business purposes; to gain the knowledge and the training that they are to use in making a living, and the teachers are paid to give this training. The students have the right to demand of their teachers the necessary time and attention on their part that will afford them this training. In this day if I were a student, especially in a state supported school and I saw a teacher of mine neglecting his work so that I suffered by it and therefrom was not receiving the training I was seeking, I should not hesitate to impeach him, to report him for neglect of duty. Nothing but the tradition, the shadow of the old halo, prevents such business-like action.

It is a little aside from the present subject; but this old halo is responsible for many other abuses around our schools, such as the keeping in their positions of men broken down in health or who have outgrown their usefulness through old age while they ambulate through Florida, Carlsbad and California in search of mended health and the fountains of youth.

And did you ever notice the kind of men most absent teachers or college presidents choose as their substitutes at such times? They are usually about like the dull, bloodless understudies that ministers choose to preach for them while they are away on their long summer vacations, men who are surely not to be preferred to the men that they represent.

I tell you all this is wrong. The business of teaching and conducting a large modern college or university requires strong, healthy, wideawake men, and our duty to these young men requires that only this kind of man should be allowed and retained in a chair.

Therefore when a man begins to fail, either from ill health or old age, let us have a good strong man in his place at once, as we do in railroad work. Take care of the old teacher who has given his all, but don't let the young men suffer by his weakness or senility. All honor say I to President Elliot, who after forty years or more at Harvard's head, lays down his duties while still in vigorous health.

As I have indicated, the government of our higher institutions should be a stringent and exacting one. The good of the students and the good name of our colleges demand it. It should not treat the student as a boy, but as he is, a man. In this country at least, it should be a democracy and should be founded upon the good will and consent of the governed. I have never seen the practice of cribbing and cheating in classes and examinations completely eliminated in any school but one, the Louisiana State University; and there it is done as it is at West Point by the students themselves. In order to carry out any wise reform, it is only necessary to secure the cooperation of the older and more thoughtful students and, forsooth, the thing is done.

One thing more and I have done for to-day with the teachers' side of this case. I see more and more in our educational journals, as well as in the attitude of individual teachers, indications that in the higher educational work of the day, the teacher's duty is becoming that of a pedagogue only; that is, that he is concerned only with the head and not with the heart, morals, or manners of the student. Now I sincerely hope that this attitude will never prevail. The teacher should be responsible for the whole man that he turns out into the world; for his integrity, his gentlemanly qualities and his public spirit, as well as for his mental qualities. Let us not separate ourselves from any portion of our inheritance in this respect. Let us not only not confer our diplomas upon an educated class of thieves and toughs, but let us not confer them upon a single educated thief or tough. But rather let us confer them, as was done in our colleges of old, only upon men who can be trusted to go out into the world and make it better by living active, useful, aggressive, honorable lives therein.

And now a special word to you students; I began this talk with a reference to your future success; and without your divining it, perhaps, I have been discussing those features of your college life upon which, in my humble opinion, your after success mostly depends, viz., your personal integrity, your personal habits, your purity of mind, and your diligence in securing personal training.

There is a mistaken notion among college men that their success depends primarily upon their mental growth and acquirements. This is a very great mistake. Your success will depend far more upon several other qualities; even when you limit the meaning of the word success to the accumulation of worldly goods. To acquire such a success you will generally find even such matters as your personal manners, your ability to look a man quietly and manfully in the eye, and to speak straight to the point, of more weight than mere mental acumen. Your ability to endure and to stick to a job, to do the same thing over and over again every day of your life, or perhaps several times a day, and to strive every time to do it better than the last, is going to count far more than your brilliant intellect. And please note that all of these qualities upon which success depends are such as can be readily acquired by men of very ordinary intellect.

Did you ever get right close to the successful men in your community, take note of their mental processes, and note how simple they are? Most successful men become so from mastering thoroughly some one simple idea or principle. It may be how to raise pigs, or it may be how to paint angel's wings.

Take them out of their special fields, however, and you may find their mental processes inferior even to yours or mine. I should dislike very much to believe that my own mental processes were inferior to those of many of the old codgers under whom I have had to work in acquiring my practical engineering experience. Some of them could not frame a sentence in clear concise King's English if their lives depended upon it. If by mischance a new thought found its way into the minds of some of them, it would seem that they were so exhausted thereby that they must take a day off and rest over Sunday before they could resume their daily occupations. And yet every one of them had one or more habits, or methods, or special kinds of knowledge which singled him out and of which it was worth while to take note.

Understand me, I don't make light of scholarship. However, scholarship is not the goal but the means of reaching the goal. I spent five years of my life in the hardest kind of drill on the Latin language. At the end of my course, I thought I knew almost as much about the uses of the Latin subjunctive as Dr. Gildersleeve himself. At Johns Hopkins, I spent the best part of a whole semester in a grind with a fiendish course of determinants under Dr. Story.

To-day I do not believe I could immediately translate correctly any one of the Odes of Horace, and I fear I wouldn't know it if I met a determinant in the road. But do you believe that I now feel that the midnight oil that I burned and the time in pursuing those studies, earnestly and diligently enough to enable me to come up to each examination with a confident knowledge that the professor could not flunk me on any fair test, were all thrown away? Why, young men, those studies were the timbers of the scaffold with which I built the house in which I trust I have since lived a useful and honorable life. The timbers of the scaffold may have long since rotted away; but the old house, such as it is, still stands and was built I hope to last for a lifetime.

If you young men are like the students that I have taught, a great many of you are wasting your time and are forming habits that fit you for almost anything else than the serious problems of life that you are soon to take up. You complain loudly, perhaps, when two of your term examinations fall on the same day. You have neglected your work so much and so persistently during the term, that you know you will fail unless you are given a chance to cram up just before going to your examinations. If you had done your full share of work day by day, during the term, you would not care if two or all of them came on the same day.

In your business life you won't have the time to cram.

The viewpoint that many of you young men absorb from your school environments is sometimes a very pernicious one. Here everything and everybody exists for you. Every teacher is glad to have you in his course; some of them entirely too glad. You cut your classes whenever you please and when you return your teacher welcomes you back. Now when you graduate and go out to real work, all this is changed. You are no longer served; but you serve; and you serve efficiently or get kicked out. In a way, that is the manner in which you ought to be treated here. Not that you should be unkindly dealt with, but that you should be held up to rigid requirements in order to get you in trim for conditions you have got to meet.

Your teachers ought to train you for life somewhat as the football coach trains his team, with an iron hand; and you ought to submit in order to win, just as do the members of the team. But under the conditions that now exist, it is no wonder that something like 90% of our engineer graduates are badly disappointed with their first year of real work.

THE SETTING OF CEMENT MORTAR UNDER COMPRESSED AIR was investigated by the Boston Transit Commission from 1901-08, and is reported upon in a table in the report of the Commission for the year ending June 30, 1910. The tests reported are very meager and do not throw very much light on the subject. A number of briquettes of different cements were made to a 1:2¼:4, cement, stone dust and ¼-in. crushed stone mixture and broken in tension at intervals from 28 days up to 7 years. One set of the briquettes was kept 24 hours in free air, 13 days in compressed air, at from 20 to 25 lbs. pressure, and the remainder of the time under water. The other set was kept 48 hours in free air and the remainder of the time under water. An average of all the tests, numbering some 25 different brands of standard cements, only one of which was duplicated in the two sets, gives the following results:

TENSILE STRENGTH IN LBS. PER SQ. IN.

	28 days.	1½ mos.	2 mos.	2½ mos.	18 mos.	7 yrs.
Comp. air.	364	400	...	435	559	598
Free air...	287	...	323	...	404	403

As there is no other evidence as to the relative strengths of the various cements under the same conditions of testing, these figures have no comparative strength value, but can only be used to observe the ratio of increase of strength.

RAILWAY BLOCK-SIGNAL STATISTICS are given in a bulletin recently issued by the block-signal and train-control board under the direction of the Interstate Commerce Commission. The total length of railroad in the United States operated under the block system on Jan. 1, 1911, was 71,269.1 miles, an increase of 3,511.1 miles over Jan. 1, 1910. Of the total, about 17,700 miles were operated with automatic signals and about 53,600 miles with manual. The increase over the preceding year was about 3,474 miles for the automatic system and 2,037 miles for the manual.

This latest bulletin includes 13 steam roads and 6 electric roads which had not hitherto reported the use of block signals. On the other hand, five roads formerly listed have been dropped out, apparently because they no longer use the block system. The total mileage of track of the 160 odd roads using the block system is 195,922.4, so that only about 36% of the total track of these roads alone, or about 28% of the total railroad mileage in the United States, is block-signaled. Meanwhile, the accidents due to the train-order system go merrily on.

There are 28 roads credited with block signals over 100% of their track, while ten others are credited with 95% or more. Many of these 38 roads, however, have small mileages, nearly half of them being under 100 miles. There are ten roads with over 1,000 miles of track each, which have 95% or more of their track block-signaled: Baltimore & Ohio Southwestern; Chesapeake & Ohio; Chicago, Burlington & Quincy; Chicago Great Western; Chicago, Milwaukee & Puget Sound; Lehigh Valley; Lake Shore & Michigan Southern; Michigan Central; New York Central & Hudson River; and the Norfolk & Western.

Comparative Tests of Large Engine and Turbine-Driven Centrifugal Pumps.

By FRANCIS HEAD.* M. Am. Soc. M. E.

At the Torresdale filter plant on the Delaware River, from which Philadelphia obtains two-thirds of its water supply, there is an installation of large centrifugal pumps for raising the water from the river to the filter beds. This pumping station furnishes 220,000,000 gals. daily and contains eight pumping units. Seven of these are engine-driven, each of a capacity of 45,000,000 gals., and one is turbine-driven of 50,000,000 gal. capacity. The station also contains the electric-light plant and the wash-water pumps required for the operation of the filters. The pumping equipment has an excess capacity over the present service as above noted.

During the past year six of the engine-driven pumps and one turbine-driven have been carefully tested for economy according to the specifications. The data obtained afford a comparison of the results which may be obtained from these two kinds of pumps, working under similar conditions.

The engines are vertical compounds of the Woolf type, in which the steam is exhausted directly from the high-pressure cylinder, through piston valves, into the low-pressure cylinder, the cranks being set at 180°. The engines are run at 177 r. p. m. and indicate about 480 HP. The cylinders are 16 and 32 ins. in diameter by 20-in. stroke. The pumps to which the engines are coupled are of the double-suction type and have two 30-in. suction pipes extending down into the intake conduit, which is beneath the pumps. The impellers are of cast-iron, about 80 ins. in diameter and of the enclosed type. The discharge line from the pumps is 36 ins. in diameter, and is connected by an elbow to a pipe of the same size, which passes through the side of the pumping station and joins a large header, by which the filter beds are supplied. Each engine is furnished with its own surface condenser, which is cooled by water taken from the pump discharge and returned to the pump suction.

Separate wet and dry vacuum pumps are provided in duplicate and during the tests three engines were run as a unit on one wet and one dry pump. The condensed steam from the engine condensers was weighed, and the steam used to run the vacuum pumps was separately condensed and measured. The total head pumped against varied with the tide and with the elevation of water on the filters. The discharge head was measured by a mercury column connected just beyond the pumps, and the suction lift was measured from the surface of the water in the conduit by a rod and float, with zero referred to the mercury column used for the pressure. In comparing the results of the engine tests with those of the turbine tests, the head lost in the suction pipes of the engine-driven pumps has been added to the head actually measured, in order to make the results comparable.

The discharge from the engine-driven pumps was measured by pitometers, of the "Coles" type, placed in the discharge pipe. These pipes had been carefully traversed by the makers of the pitometers, the Pitometer Co. of New York City.

The entire test of the engines extended over a period of 30 days, during which the condensed steam was weighed and readings were taken at 15-minute intervals. In addition, the coal was weighed and the usual boiler-room readings were taken to reduce the pump duty to a coal basis. As the guarantee was especially high for the first 24 hours, the writer has used only these results in this comparison.

The turbine test lasted for 12 hours, which was sufficient to cover periods of high and low tide. The turbine pump was of the De Laval type and has two 24-in. pumps discharging in parallel around the tubes of a water-works type, surface condenser. From the condenser the water passes through a 42-in. pipe to the main leader outside the building. The impellers are of the horizontal, double-suction, enclosed type, about 24 ins. in diameter and are made of bronze. The pump shafts are driven at a speed of 742 r. p. m. by a 500-HP. geared turbine, running condensing. A "Rotrex" air pump is driven by a silent chain from one of the turbine gear shafts, which makes the unit self contained. By a separate test, using a motor, it has been found that about 5 HP. is required to drive this air pump.

Owing to the turbine pump having been installed after the rest of the machinery had been planned and the station built, its suction pipes were put down a square man-hole which had been left in the intake conduit. This necessitated several bends in the suction and increased the suction lift slightly. The discharge head was measured as before with a mercury column connected to the discharge pipe leaving the condenser. In this way the pump does not get credit for the head lost in the condenser, which is about 5%.

The average suction lift was measured by mercury columns placed on each suction pipe near the pumps. The pump discharge was measured by a "Coles" pitometer during half of the test in the regular way. On the other half of the test, as a check, the down stream end of the Coles tube was disconnected from the manometer and the manometer was connected to piezometer taps placed on opposite sides of the discharge pipe. These results were found to agree within 1%. The pipe had been previously traversed and the piezometer measurements were in charge of the same observers as on the former tests.

The condenser discharge was weighed and readings were taken at 10-minute intervals throughout the turbine test. The turbine condenser was subjected to pressure before the test and the engine condensers were tested afterwards. Both proved to be tight. The cylinders of the engines, their piston rings, valves, etc., had been carefully overhauled and adjusted by their builders and both the engines and turbine were handled by their builders during the tests.

The readings during the tests were taken separately, both by the contractors and by a set of skilled observers for the city, and checked afterwards.

The tests were run in strict conformity with the specifications and contract, but the results as given below have been modified, as explained, to make them directly comparable. In obtaining the results given below, the slide rule has been

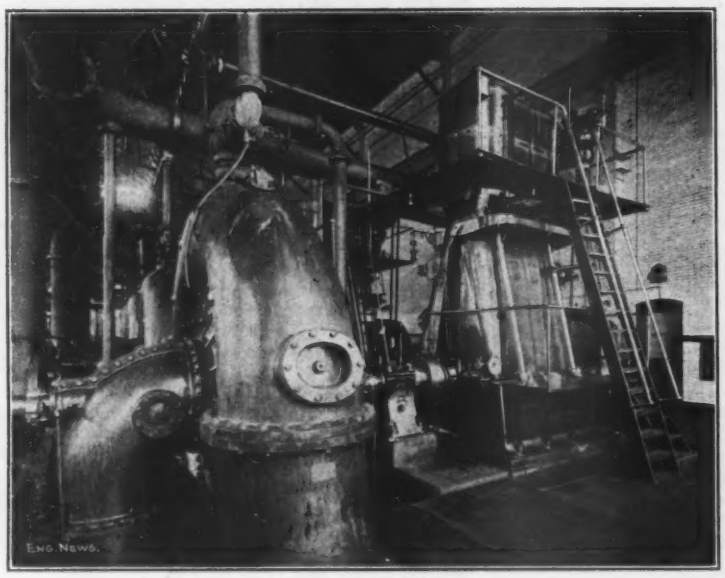


Fig. 1. Engine Driven.

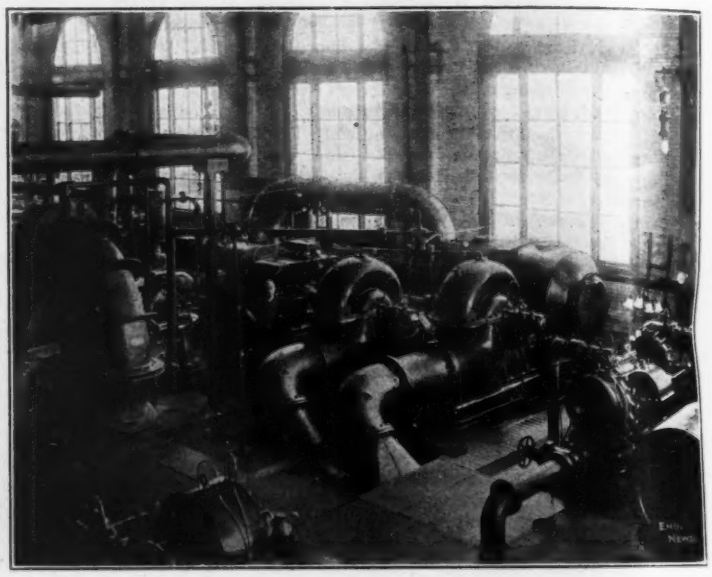


Fig. 2. Turbine Driven.

FIGS. 1 AND 2. PUMPING UNITS IN THE TORRESDALE PUMPING PLANT, PHILADELPHIA.

COMPARISON OF TEST DATA: ENGINE AND TURBINE DRIVEN PUMPS; TORRESDALE PUMPING STATION, PHILADELPHIA.

	Turbine.	Engine.
Date of tests	Jan. 13-14, 1911.	Oct. 20-21, 1910.
Steam pressure at throttle	173.3 lbs.	.....
Steam pressure at boiler	.....	175.5 lbs.
Superheat at throttle	53.2° F	.....
Vacuum in turbine case	28.8 ins.	.....
Vacuum at wet vacuum pump	.....	26.26 ins.
Revolutions per minute	741.6	177.4
Water pumped, gals. per 24 hours	49,750,000	47,850,000
Total head	44.71 ft.	43.27 ft.
Water horse-power developed	390.09	363.09
Steam used per hour without condenser pumps	7,398.3 lbs.	8,359.8 lbs.
Steam used per hour by condenser pumps	.....	170.5 lbs.
Per cent. of steam used by condenser pumps	.....	2.04
Steam used per hour per water horse-power without condenser pumps	18.96 lbs.	23.18 lbs.
Saving of turbine over engine $= \frac{23.18 - 18.96}{23.18} = 18.2\%$		
Duty, million ft.-lbs.; work done on the water per 1,000 lbs. of steam, not crediting pump with head lost in condenser	104.4	.....
Duty without charging steam used by vacuum pumps	.....	86.0
Duty, assuming two-thirds of vacuum pump steam to be saved by heating feed water	.....	85.4

*Mechanical Engineer, Bureau of Surveys. In charge of Sewage Pumping Station Design, 109 West Chelten Ave., Germantown, Philadelphia, Pa.

used, as its accuracy exceeds hydraulic measurements of this character.

The effect of the rise and fall of the tide on the quantity discharged by the pumps, and the duty is shown on the accompanying curve. It will be noticed that the water horsepower delivered by the pumps remains nearly constant, the discharge increasing as the head diminishes.

The duty shown by the engine-driven pumps is quite high for this type of pump. Of the six engines tested, three at a time, the test of the three which gave the best results have been used. The other set gave 1.75% less duty.

CONCLUSIONS.—The tests as outlined above are not sufficiently comprehensive to enable the drawing of broad conclusions covering the exact relative economy of the two types of pumping units. Each case should be studied individually on its own merits. But from these tests, taken in connection with others made on the same units, and from a year or so of operation, it would appear that (1) the turbine pump required less steam to do the same work; (2) oiling and attention were in favor of the turbine since the machine is low and the oiler can easily reach all parts and since no cylinder oil is used; (3) the larger water passageways and the more rugged construction are an advantage in favor of the engine-driven type; (4) for continuous operation the turbine seems to be the easier to maintain.

The engines and pumps described above and shown by Fig. 1 were built and installed by the Camden Iron Works, of Camden, New Jersey. The turbine (Fig. 2) was built by the De Laval Steam Turbine Co., of Trenton, N. J., and installed by the Dravo Doyle Co., of Philadelphia. On neither contract was any bonus specified. The writer was in charge of the tests for the city.

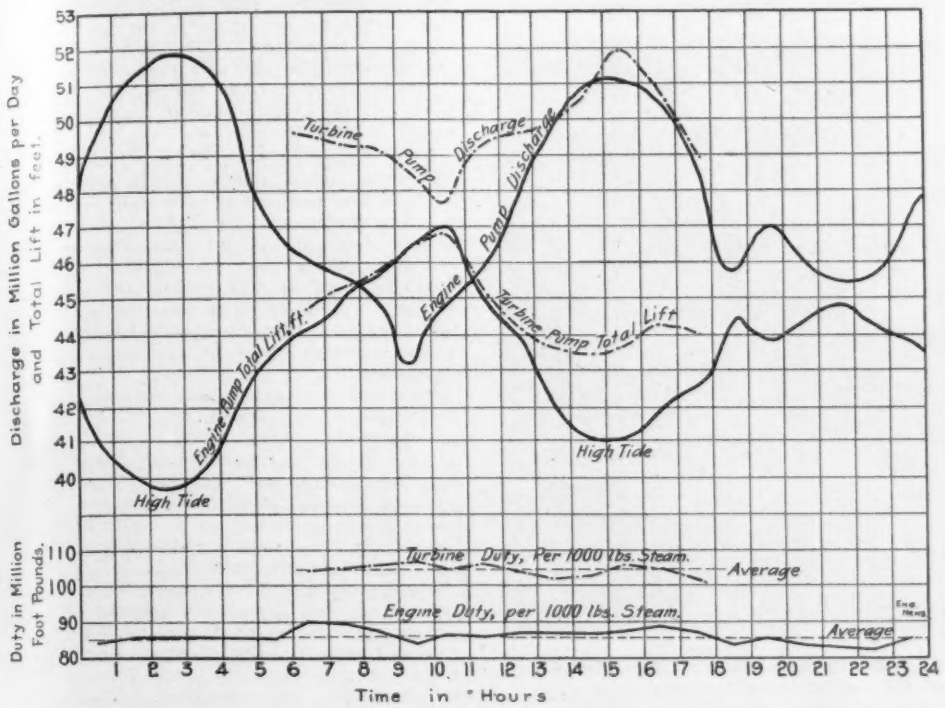


FIG. 3. DIAGRAM SHOWING TEST RESULTS OF ENGINE PUMPS, NOS. 4, 5 AND 6, AND TURBINE PUMP, NO. 8, TORRESDALE PUMPING STATION, PHILADELPHIA.

A NOTED STEAM-HAMMER was put out of service at the Krupp works, Essen, Germany, on March 4, 1911, after 50 years of service. The hammer, baptized "Fritz," had a 50-ton ram and a 1,000-ton anvil. It was single-acting, working with free fall. The cylinder had a diameter of 54½ ins. by 10 ft. 4 ins. stroke; the piston rod was 10½ ins. in diameter. The steam valve was manipulated by hand, a speed of 10 to 12 blows per min. being attained. The machine was a radical innovation at the time Alfred Krupp built it, and for 30 years remained the most powerful tool of the company's forge-shop. In 1890 a 2,000-ton forging-press superseded it, but the hammer has been kept in service. Now it is to be taken down and its work done by presses. Its last working shift was made the occasion of a celebration, in the presence of the owners and managers of the works. "Stahl und Eisen" of March 23 reports the event.

The Security of Irrigation Bonds.*

By WALTER E. LAGERQUIST.

The popular interest in the conservation of our resources and the Government's activities in reclamation have aroused the public interest in arid lands. Government officials have estimated irrigation investments in this country for the last two years at about $300,000,000. But is this phenomenal growth stable? Is there enough security back of these bonds to warrant their safety? Some of the failures of the past two years might almost indicate a possible repetition of the failures under the Wright Act in California during the '80's.

Irrigation without question does afford some of the best secured and highest paid form of investments; but every irrigation enterprise is not successful. About the only lien for a number of these new and untried issues are their elaborately colored prospectuses.

MUNICIPAL OR IRRIGATION DISTRICT BONDS.—Irrigation district bonds are issued by organized districts for the purpose of projecting a new enterprise, purchasing an established system or completing an undertaking. A district desiring to issue these bonds is organized into a quasi-municipality and is authorized to issue bonds after the manner of a municipality in the issue of city water bonds, i. e., they must be approved by the resident taxpayers of the district. The interest and the principal of these bonds are secured by a prior lien upon the properties within the limits of the district. The payments are met by a tax levied on the lands within the prescribed district.

CARY ACT BONDS.—In order to hasten the settlement of arid and unoccupied lands, the Cary Act of 1894 was passed, and has since been amended twice. By this act the Federal Government could give to the various arid states, unappropriated lands within their respective borders, not to exceed one million acres, in consideration of the states supervising the reclamation and the selling of the land to actual settlers. This has been increased to two million acres in Idaho and Wyoming.

Seven states have passed legislation appropriate to the requirements of the act. These tracts are to be sold in plots not to exceed 160 acres to one person, while at least 20 acres must be irrigated and put under cultivation in each plot.

Private companies were rapidly organized to secure these privileges. After the proper filing of their application and acceptance of their bond, a private corporation can appropriate water rights in state streams and reclaim these lands under the supervision of the state; the Federal Government agreeing to give the corporation a first lien, by which the land will not be sold until the settler has secured from the corporation the corresponding perpetual water rights to his land.

The purchase of these water rights by the individual from the corporation is made under the "Cary Act contract" which forms the real security for the "Cary Act bonds." The charge is generally from $25 to $40 per acre, of which a 10% cash payment is required, while the settler gives promissory notes for the remainder.

*Condensed from an article in "Moody's Magazine" for April.

After the patent is issued by the Federal and State governments, which for example in Idaho is two years, the water contracts become first liens upon the land and corresponding water rights. Thus, in Idaho at least two years must elapse after the completion of the irrigation works, before the "Cary Act bonds" have any securities of consequence back of them, and the so-called statements "of first liens on lands," at the time these bonds are sold is merely a future possibility.

PRIVATE CORPORATION BONDS.—It would be impossible in a brief article to state all the differences to be found in the various private corporations. The most of them, however, fall into two classes, first those corporations whose security to their bonds consists in the control of the water system and canals; the second, the corporations whose security is on the water system, canals and land.

In the first instance the company's payments depend on its efficiency in the transportation of its water. This makes the company a common carrier and consequently subject at the present, at least, to restrictive legislation. Companies of this character, as in Colorado, have been known to suffer considerable loss from such legislation. The possessor of such securities would also experience considerable difficulty if he attempted foreclosure, in establishing his rights at equity over those of the owner of the land.

In the second form of corporate enterprises, the bonds are a lien on all the property owned by the company. The payment of these bonds, then, depends upon the sale of land to settlers and not upon the earning capacity of the land. If conditions are unfavorable for the sale of these lands, it generally means that the bonds become defunct. The ordinary practice in a company of this type is to organize two companies, namely, a Land company and a Water company. The Land company will mortgage each tract of land to the Water company (this mortgage is assumed by the individual settler) for the accompanying water-right of that tract. The Water company then bonds its properties and deposits these bonds with a trust company as collateral security for the bondholders.

As it is impossible under the "Cary Act" for an irrigation company ever to acquire one acre of land, the widely advertised assertions of many companies, that these lands are securities are not true at the time of the sale. This "lien" can only be made against the settler himself and his water right. Even if the settler is allowed to take the direct title to this land, as he is permitted in a few states, the "Cary Act" still makes the mortgage, if contracted, non-enforcible. In addition to this, the companies of more doubtful standing are compelled to issue the greater part of their bonds before any construction work is really begun. What security is there offered to these bondholders? Nothing, but the good-will of the corporate enterprise, consequently the mortgage feature of the bonds is chiefly fictitious.

The tangible values guaranteed in the issues of private corporations are often more worthless than either the "Cary Act" or "Municipal" securities. A private enterprise of the first type will often float a bond issue at the rate of 1½ of possible future water rights to 1 of bonds, whose only security is this same water right of the future. It must always be borne in mind that this security is not tangible till the works are completed. If the proper estimates have been made, so that the work is carried to completion it may prove a safe investment, but at the time of the bond sale it cannot be considered other than the highest type of speculation.

The second general type of private corporation which offers the security of both the land and the accompanying water-right has the same objectionable feature. If it is an entirely new enterprise in an arid region, the land is generally utterly worthless till water is available. But the real success of the concern depends on the ability of its promoters as agents, for the whole income of the company must come from this source. It is this class that needs to be closely scrutinized by the investor. Some of these companies have advertised immense tracts of land with the accompanying water-rights for sale while as a matter of fact, their actual land holdings are very small.

The lack of a legitimate amount of capital stock in proportion to the issue of bonds also shifts to the bondholders a great part of the risks which in any conservative new undertaking belong to the stockholders.

The costs of private corporations, even under far more favorable circumstances than have been enjoyed by some of the Government's enterprises, have been 30% higher than the Government undertaking. There is no limit to these costs and they are especially large in the question of salaries and dividends. The costs are also inflated by the contractors in another way, especially in municipal districts. The contractors, in order to procure the work, accept a part of their payment in bonds of the company, but in order to obtain cash for these bonds, it is necessary to sell them at a considerable discount to bankers. They must inflate their original costs to a considerable extent in order to receive their full costs. This again inflates the paper valuation of the company's assets and adds to the instability of the security.

The district irrigation bonds are the best form of irrigation securities from the investment standpoint, if the work is completed within the proposed period. If the

project, however, is not completed within the proposed period, the settlers, if wholly dependent upon this water supply to cultivate the land, are probably unable to meet the tax. The only security back of these bonds may then all be worthless land.

In addition to this, as is often the case, a large part of the area may be Government land, which is not subject to a tax until homesteaded. This again lessens the worth of the security, for the burden is all placed on the remaining land of the district to be benefited, which becomes especially burdensome, if sparsely settled.

The irrigation districts under the Wright Act experienced this very thing. The cost of the irrigation system was so great and the districts so slowly settled that the bonded debt was more than the population in the district could meet by taxation. They sought safety by law, and the bonds were either repudiated or reduced in principal and interest. It is quite evident, then, that the payment of these bonds does not depend on any original values or present earning capacity, but on the future completion of the project.

The "Cary Act" (unlike the cooperative municipal districts which gave them strong personal interests and responsibility) leads to a wide diffusion of responsibility. The short tenure of state officials and their desire to hasten the development of the state, when he does not feel the weight of future responsibility, is more apt to lead to a hasty approval. But even a still greater weakness is the fact that an individual investor has no basis of physical valuation in which to base his estimate; he must depend altogether on the opinion of experts. And is it not possible that in the questions of slope, topography, alkaline salts, subsoil, exposure, frost lines, nearness of mountains and forests, drainage, evaporation, productivity, former character of vegetation and so forth, that some of the opinions of the expert may be wrong? If a mistake has been made, the loss will generally be shifted to the ignorant bondholder.

NEW WEIR TESTS OF LARGE RANGE are in progress at Cornell University, Ithaca, N. Y. Profs. K. B. Turner and E. W. Schoder are conducting them. Prior weir investigations in the large Cornell hydraulic laboratory were based on the use of accepted formulas, themselves based on small-range tests. The new investigations will be completely independent, involving direct measurement of the water and as they will extend to a range several times as great as that of previous standard experiments, the results will be of great importance. The tests will deal primarily with sharp-crested weirs of lengths from 1 to 16 ft., with heads up to 7 or 8 ft. and heights above channel bottom up to 10 ft. Submerged weirs will also be tested. Dr. Schoder is utilizing for this work his half-year Sabbatical leave of absence.

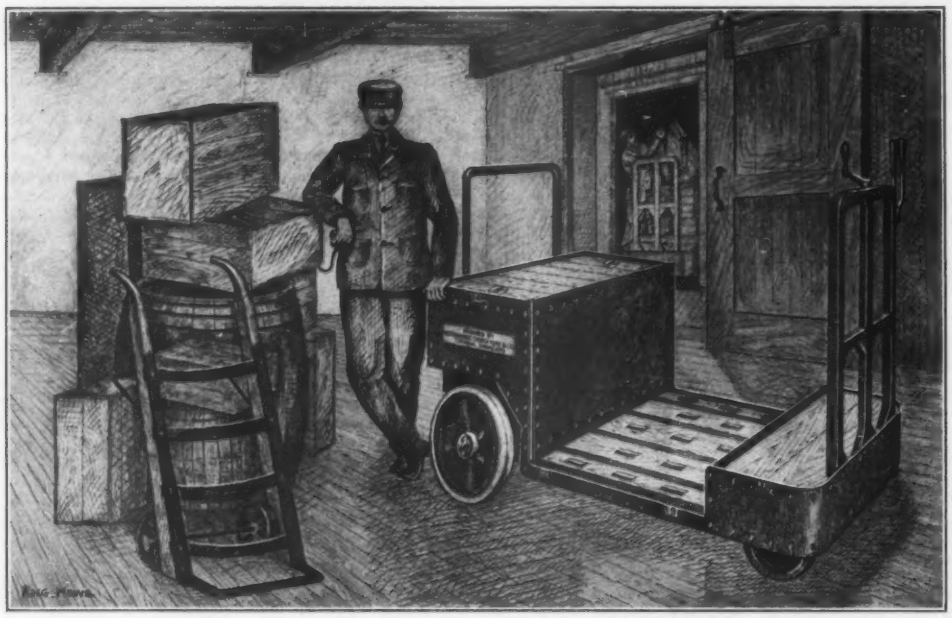
A PUBLIC SERVICE COMMISSION FOR MASSACHUsetts in place of the present State Railroad Commission is recommended by Governor Eugene M. Foss as a result of the investigation made by Clinton H. Scovell. Gov. Foss says:

> In my judgment the only remedy is to centralize the work of supervising public service commissions in the hands of a competent board of managers, with broader powers, constituting a public utilities board, who shall be required to devote their entire time to the service of the state and be held rigidly to account for the full discharge of their duty.

A Storage-Battery Truck for Handling Package Freight in Railway Freighthouses.

A distinctly new treatment of the pressing problem of bettering freighthandling facilities in railway freighthouses has been worked up by Mr. George B. Francis, of Westinghouse, Church, Kerr & Co., New York City. In the active discussion of this problem during the past few years, overhead conveying machinery received chief prominence, and the central idea has been to do away with movement along the floor of the freighthouse. Mr. Francis, however, proposes to improve the floor movement by substituting power trucks for hand trucks.

The idea, it is said, sprang from the successful operation of power baggage trucks in the new Pennsylvania R. R. Terminal in New York City. It appeared that similar trucks, somewhat modified to suit the altered requirements, should be as successful in handling packages of freight as in handling trunks and traveling bags. From this thought resulted the design shown in the view herewith (photographed from a pen sketch). Mr. B. H. Smith, M. E., assisted Mr. Francis in developing the details of the truck. Patents have been applied for.



A STORAGE-BATTERY TRUCK DESIGNED BY GEO. B. FRANCIS FOR HANDLING PACKAGE FREIGHT IN RAILWAY FREIGHTHOUSES.
(Capacity, 1,000 lbs.; weight, 1,200 lbs.; max. speed, 6 mi. per hr.)

What follows is an explanation of the conditions calling for the use of such a truck, and a description of the construction of the machine, written by Mr. Francis and reproduced with only slight condensation:

At outbound and inbound freighthouses of railways, it is necessary to move all sorts of packages from any one spot to any other spot, sort the packages in the outbound house for classification so that the proper rates may be applied to the particular weights of individual consignments, and again sort them so that the individual consignments may be trucked to the right car for destination. It is also necessary to have some positive method of checking so that truckmen do not leave the packages in the wrong car, through carelessness or inadvertence, without its becoming instantly known to those in charge.

At the inbound house there is no need for weighing and classification therefore, or sorting for destination other than to place the package in the proper section of the house for final delivery to teams. Thus the movement of packages from any one spot to any other spot at the inbound house is more simple than at the outbound house.

Up to the present date, no method of moving packages in these two kinds of houses has been found equal in efficiency or more economical in cost than the hand truck and hand power, which have been with us from time immemorial.

Great effort has been made to devise a system of overhead carriage or telpherage, to embrace lifting, conveying and lowering, say from the time freight is delivered at the doors of the outbound house by teams until it is deposited inside or upon the car in which it is to be transported over the railroad; also to make this apparatus workable in handling any kind of package from any one spot in or alongside of the house, to any other spot in any car in any part of the railroad yard adjacent to the house. Such a system involves overhead tracks everywhere in the house and yards sufficient to cover almost every square foot of area, the distribution of contact wires for power, the use of many switches in the track, automatic or otherwise, for diverting of route, etc., etc. When it is tried to lay it out, in connection with existing facilities, it is found that to get supports for the overhead track this telpherage system practically requires the reconstruction of entire yards and buildings. There are often physical obstructions, like overhead bridges, etc., to prevent the utilization of headroom over the cars, etc.

These difficulties have prevented railroad officers from installing such plants, and there is hardly a demonstration of such a system throughout the length and breadth of the country. Should any railroad manager have sufficient confidence in obtaining the reduction of cost in freighthandling by this system, the best place to try it out would be in an entirely new terminal where all facilities could be planned together with this system of handling in full contemplation.

Over and over again have railroad men and their engineers repeated the statement that nothing would ever be found to take the place of that wonderful tool called the "hand truck," so efficient in all save expense, in moving the package freight in the freighthouses, and a eulogy might be written on its utility as a crowbar, elevator (at least sufficiently to clear the floor), turntable and conveyor.

The American Railway Engineering and Maintenance of Way Association assigned this subject to a Committee on Yards and Terminals in 1908 and again in 1909. The following extracts* are taken from the report of that committee (Mr. F. S. Stevens, Superintendent, Philadelphia & Reading R. R., Chairman):

> There appear to be no conveyors in use in ordinary freight houses. * * * In a few cases, conveyors are used for loading and unloading cars at industrial establishments and at steamship piers.
>
> Freight handling by machinery may be divided into two classes: (1) In warehouses and steamship piers, where the movement is mainly longitudinal; (2) in freight houses, where there are numerous movements in different directions. The former case is much the simpler, but it may be found practicable to introduce mechanical handling, so as to reduce the amount of trucking in the latter case.
>
> The Committee calls special attention to the opinions quoted below * * *
>
> (By Mr. Starr, Pennsylvania Lines.) The Pennsylvania System has, so far as I know, no machinery whatever at freight warehouses for the purpose of handling freight from and to platforms, in or out of cars, nor for the purpose of transferring between cars.
>
> (By Mr. F. P. Abercrombie, Supt. New Jersey Division P. R. R.) In relation to the use of freight handling and conveying machinery in railway freight houses, transfer houses and warehouses, I beg to advise that, with the exception of fixed and traveling cranes, which are a necessity, I know of no machinery such as movable platforms, overhead trolleys or conveyors, that would in any way increase the efficiency of a proper truck service, or take the place of such service. We have no freight houses that are equipped with other than trucks and suitable cranes.
>
> (By Mr. Stevens, Chairman.) We have made numerous investigations, and have had a great deal of correspondence with people who have manufactured appliances of this kind and with those who thought it desirable to install them, but have not yet found any one who has been able to recommend a telpherage system or transfer system of any kind as applicable to the transfer of miscellaneous freight. * * * There is nothing that we have been able to discover except a hand truck that covers the requirements.

The tool now suggested to take the place of the expensive hand truck is nothing more or less than a miniature storage-battery power truck, which improvements in batteries and other apparatus have made available for the purpose. The development of this miniature truck is a natural following on the immense success achieved

*See also abstracts of the reports of the Committee on Yards & Terminals, Eng. News, March 26, 1908, p. 340; March 25, 1909, p. 313; April 13, 1911, p. 463.

by the recently adopted larger power trucks for baggage handling in New York and other places. The best features of the miniature truck are: its availability in all existing freighthouses and the low cost to any railroad to make a demonstration of its efficiency. The machine has been named the "Motor Dolly," based on the fact that the timber "dolly" used on construction work is the smallest known type of machine used for the conveyance of heavy weights.

The object of the motor dolly is to provide a handy apparatus or tool for use in handling l. c. l. or package freight, primarily in outbound and inbound houses, and by its use to supersede as far as may be possible, and in every case to supplement, the present hand truck by a power truck of such size and general characteristics as to enable railroads to materially increase present freight terminal capacity without expensive reconstruction. Its use will reduce that portion of the cost of freighthandling chargeable to terminals.

The overall dimensions selected are those considered most desirable for present outbound freighthouse conditions. The average working speed of the motor dolly will be twice that of the hand truck and the average carrying capacity utilized about three times that of the hand truck. This makes the power dolly, when efficiently used, equivalent to six hand trucks in speed and capacity.

The machine suggested consists of a steel-frame spring-mounted platform 6 ft. long and 38 ins. wide. The front and rear portions are raised, the rear to accommodate the power plant and driving gear, the front to provide clearance for the steering wheels. The central portion, which is but 9 ins. above the floor, is intended for heavy packages while the raised portions are for light packages. The entire platform area is available for loading. The central or low portion is provided with a unique and original system of depressible rollers for convenience in loading and unloading. During transit these rollers are depressed, allowing the package to rest directly on the platform. By means of these rollers, large or heavy packages ordinarily requiring considerable time and labor for loading may be readily slid on and off the platform, thereby materially facilitating this portion of the work and enhancing the value and adaptability of the motor dolly for freighthandling.

The space occupied by the suggested motor dolly is approximately the same as that occupied by a loaded hand truck in transit with the trucker either pushing or pulling the load. The maximum speed practicable is 6 mi. per hr., while the average speed will be about 5 mi. per hr.

The turning radius is 2 ft. at the rear wheel, which allows of its use in as cramped and congested situations as that in which the present hand truck operates. No wider trucking aisles are required than with the hand truck.

The power plant consists of a storage battery in connection with a compact and efficient motor of 2 KW. rated capacity. As one of the chief requirements is rapidity of movements, or liveliness, a motor capable of considerable overload capacity is required. Similarly all details of the propelling mechanism should be extremely rugged and capable of rough handling without injury.

The battery should be removable, with the idea of recharging batteries independently of the machine; spare batteries should be provided for this purpose. It is considered that under ordinary conditions of operation the battery provided will give about five hours' operation without change or recharging. The time required for battery change is about five minutes.

The motor is hung on the main frame directly under the battery and is direct geared to the countershaft through the medium of a spur gear reduction. The countershaft runs the width of the machine and is provided with a differential gear. At each end of the countershaft there are sprockets engaging a chain running on sprockets directly connected to the driving wheels. The rear axle is solid, of ample strength and rugged construction.

After providing for the several details comprising the motive power equipment, it will be seen that the space allotted to this purpose is reduced to a minimum. The same may be said of the front portion of the machine. Therefore any increase in the length of the machine within reasonable limits for inbound house conditions would represent net increase of the heavy-load portion or low platform section.

The body of the machine is mounted on coil springs, guide pedestals similar to standard railroad car pedestals being provided. The front wheels are separately pivoted and are operated for steering in the same manner as in standard automobile practice, except that greater freedom of movement is allowed.

The front vertical frame carries the control handles. The removable steering handle is connected through a vertical shaft and suitable reduction to the steering wheels. The automatic controller handle is connected to a compact controller under the front floor, which gives three speeds in both directions. The brake lever works through the usual connections on a brake drum directly connected to the rear wheels. These brakes are of the internal expanding type.

The operator may either stand on the front platform or sit on the folding seat which is hung on the front frame. In case of the front platform being occupied by packages he may readily sit on the packages. The automatic controller returns to the off position when released, so that in normal operation it requires small mental effort on the part of the operator to shut off power and apply the brakes. The brake is further provided with means for holding at any position in which it may be placed. It is considered that in view of the quality of liveliness possessed by this machine, this refinement of control is justified.

The maximum capacity of the motor dolly is 1,000 lbs. and the weight without load about 1,200 lbs. It is expected that under average conditions the capacity utilized will be about 750 lbs. and the average speed, excluding stops, will be about 5 mi. per hr.

At the rear of the machine a removable rack or stakes will be provided. These latter may be used as levers in case of necessity to assist in loading.

SUMMARY.—No greater space than is now provided for hand trucking is required for the motor dolly. It will readily manoeuver wherever the hand truck will; it can enter the standard freight car and turn around inside if necessary. In general, it represents a compact and lively counterpart of the hand truck with the additional desirable feature of speed, carrying capacity and freedom of movement.

These features are obtained without rearrangement of the present freighthouse, without the limitations of fixed overhead trackage with its special supporting structures; without a network of switching apparatus, without the danger incident to package transportation overhead, and without trolley wires or other exposed electrical apparatus. No other transportation medium, other than a charging plant, is necessary for the complete and efficient utilization of present freighthouses as they now stand, with the installation of this form of transportation in such quantities as is required by the volume of freight handled. The net capacity of the freighthouse will be increased and the initial investment, operating costs and capital charges will be in direct proportion to the amount of freight handled. This system serves areas and not predetermined fixed points whose locations cannot be changed except at considerable cost.

In order that no freight shall be sent to its wrong destination, pockets are provided for the car numbers, which instead of being handed to the trucker (as usual) are placed in a pocket opposite the freight itself, and after the freight is placed in the correct car the checking numbers are taken from a similar pocket on the car in which the freight is placed and this duplicate number put in the proper pocket on the dolly, so that on the return of the dolly to the loading point the checker may verify the fact that the several loads on the dolly have each gone to the correct car for destination.

This avoids any mixing of cards in the hands of the operator of the dolly.

The use of a motor dolly of this character probably requires in some instances that the facilities for weighing the packages as they come off the teams and before they go on the dolly shall be at the door when the transfer from team to dolly is made. In other cases where the freight is of one classification the dolly can go to the scales as usual with hand trucks.

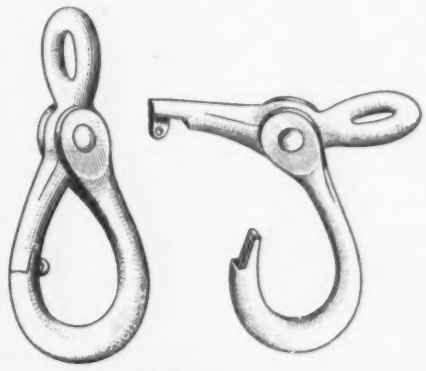
A portable platform scale could be used at the receiving doors to supplement the usual house scale.

A Self-Closing Safety Crane Hook.

Shackles and mousing hooks are used ordinarily only under conditions which make it particularly likely that the rope or chain would become disengaged from an open hook. The bother and the time consumed in using them make them unpopular for work where the load is to be frequently attached or detached. The accompanying illustration shows an improved form of safety hook which is designed to be self-closing and should therefore be nearly as convenient to use as a plain hook, while having the superior security of a shackle. It is intended for hoisting under conditions such that open hooks cannot be relied upon and to replace shackles where frequent and quick changes have to be made.

The device consists of two parts, the hook proper and the guard finger, which are hinged together at the top by a steel pin. The guard finger is made in one piece with the eye by which the shackle is attached to the hoisting line. Just below the eye a slot is punched in the guard-finger piece, into which is inserted the flattened upper end of the hook shank. The flattened portion is punched or drilled to receive the 1¼-in. pin which passes also through the walls of the slot and thus holds the shank end in place.

The lower end of the guard finger and the point of the hook are halved together, so that the joint is smooth and when the hook is closed it appears like a solid eye or link. A lug projecting from the end of the guard finger enters a slot in the



The Norden Self-Closing Safety Crane Hook.

point of the hook and serves to transmit some of the load to the finger, thus diminishing the bending stress in the hook proper. The lug is made long enough to extend clear through the hook point and has a hole drilled near its end in which a cotter pin can be inserted, if desired, to securely lock the guard finger in place.

It is evident that the hook can be easily opened when empty, but when loaded it will close automatically and the guard finger will be held against the hook point. In order to make the finger press with some force against the hook, the center of the hinge pin is set 3/16-in. to one side of the center line through the hook, as shown in the illustration. It is claimed that the resulting pressure on the hook point is of service in preventing the straightening out of the hook under an excessive load.

This device is the invention of Mr. F. F. Norden, of New York City, and is being put on the market by E. W. Marvin, 115 Broadway, New York, N. Y. It is made of vanadium steel in three sizes for respective loads of 3, 10 and 18 tons.

The Mechanical Handling of Package Freight.

By M. B. WATERMAN.*

The problem of cheapening and expediting the handling of miscellaneous package freight at railway terminals does not find its solution in designing new machinery, but rather in applying well-known devices to the handling of freight and designing an entirely new type of terminal adapted to the use of machinery. An entire rearrangement of the present methods is required.

The manner in which the railroads have been trying to solve this problem is similar to the manner in which the first automobiles were constructed. These had all the appearance of a horse-drawn vehicle with the engine hidden in the body. As automobiles came into more general use, and were found valuable, the manufacturers realized that the old carriage body was not well adapted to the engine, and gradually developed a suitable body. We are now in the first stage of the freight-handling problem, where the railroads are endeavoring to hide the mechanical system inside of the present terminal.

EXISTING CONDITIONS.—The present terminals are now taxed to their limit, and no additional men can be put on, as they are already in each other's way. Each hand-truck is now carrying its maximum load at its maximum speed.

It is evident that to increase the capacity we must increase the unit movement. It is equally apparent that if machinery is to replace the hand-truck, the unit movement must be increased to a point where it warrants the investment; that is, instead of taking 250 lbs. on a hand-truck at a speed of 100 ft. per min., we must carry a load of 1,000 lbs. or 2,000 lbs. with a telpher at a speed of 500 ft. per min. or more. In many terminals the conditions are such that it seems absolutely impossible *under the present system* to obtain such an average load. This is especially true of outbound and transfer freight. With inbound freight alone, it is possible to obtain almost any kind of a unit load, for the reason that all of the freight from every car is taken to the inbound house. The usual terminal handles both inbound and outbound freight, and often combines these two with transfer freight.

Outbound freight is usually received at the terminal from shippers throughout the city in drays, and after being unloaded, checked and receipted for, is weighed, classified, and sorted for trucking to the cars. It may be found that each package in a dray load is consigned to a different destination, and therefore must go into a different car. The present method is to take each piece separately, after it is weighed, and truck it to the proper car, no matter whether it is a 10-lb. package or a grand piano. A truckman is never allowed to take packages for more than one car, as his intelligence cannot be relied upon to put the various packages in separate cars, and there would be no check on his work.

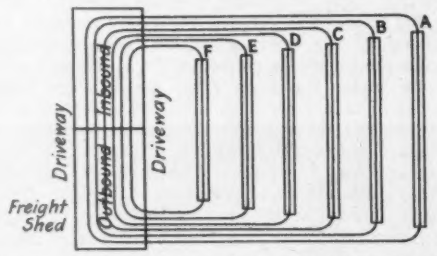


Fig. 1. A Possible Layout for a Railway Freight-house Handling Inbound and Outbound Package Freight.

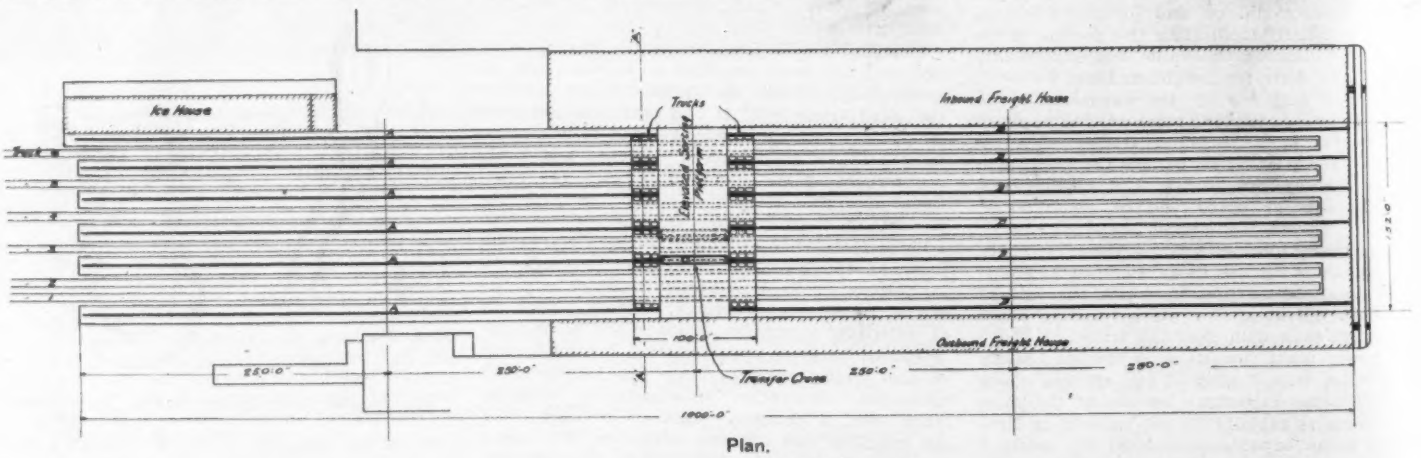
SEPARATING CAR LOTS.—It seems that the solution of this part of the problem lies in collecting the packages for any one car into one lot on the receiving platform, and then transporting this lot by telpher to its proper car. This would give the desired increased unit movement. Take, for example, an outbound terminal accommodating 100 cars. The idea would be to have a space reserved in the outbound house or receiving platform of sufficient size to accommodate at least 100 trucks (or flatboards or carriers) to be picked up by the telphers. Each one of the trucks would represent one of the railroad cars.

As the packages are received by dray they are checked up and weighed as usual, then placed on the proper truck or flatboard carrier. As soon as one carrier is loaded with a sufficient number of packages for a particular railroad car, it is picked up by the telpher, transported, and set down near the proper car door. The next returning telpher leaves an empty carrier in the space occupied by the one just removed.

The space occupied by these 100 truck loads, assuming each truck 8 ft. long by 4 ft. wide, would be 3,200 sq. ft., or a space 16 ft. wide by 200 ft. long. An ordinary outbound house is usually about 50 ft. wide and 400 ft. long, having a floor space of 20,000 sq. ft. As a matter of fact, the number of trucks would in practice be less than 100, as often several cars are loaded for the same destination. Therefore it does not seem unreasonable to believe that a proper terminal could be designed to take care of the required number of trucks without congestion.

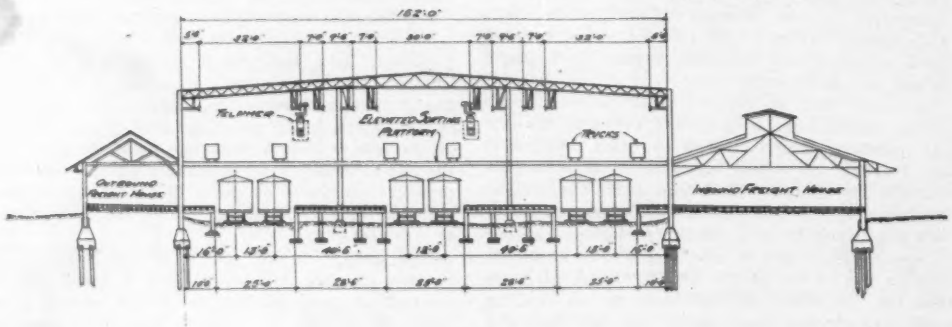
TRACK AND OVERHEAD LAYOUT.—The next step in the application of the mechanical conveying system is laying out a suitable arrangement of railroad tracks and overhead runways to accommodate a sufficient number of telphers to handle the maximum tonnage of freight. It must be so arranged that the machines can move freely between the freight house and the railroad cars without interference.

While it would be desirable to eliminate all hand trucking and all rehandling, and to have the system cover every square foot of floor space and be absolutely flexible, it is not considered practicable at the present time to fulfill all of these conditions to the letter. That would mean the almost instantaneous evolution of a perfect system, such as has no precedent anywhere in the world. It is considered possible, however, to approach these conditions so that perhaps 75% of the hand trucking can be eliminated, most of the floor space can be covered, and a sufficiently flexible system can be developed (with some aid from the hand truck, which is a most efficient machine for short distances), which will greatly increase the capacity and decrease the cost per



Plan.

Side Elevation.



Section A-A.

FIG. 2. A LAYOUT FOR A RAILWAY FREIGHT STATION HANDLING TRANSFER FREIGHT IN CONJUNCTION WITH INBOUND AND OUTBOUND FREIGHT.

*Engineer for the J. M. Dodge Co., Philadelphia, Pa.

ton of handling, and which will warrant the investment.

Inbound and Outbound Terminals.

One form of layout for an inbound and outbound terminal house accommodating 100 cars is sketched in Fig. 1. Each one of the platforms A, B, C, D, E and F is about 400 ft. long, and there are two railroad tracks between platforms. Each of the telpher runways over a platform forms a closed loop having a return path through the freight shed. The result is that we have six independent closed loops, and the idea would be to have on each loop one, two, or three machines as might be required to handle the freight.

The total length of the telpher runways is approximately 7,300 ft. The length of the longest loop (A) is about 1,500 ft., and the shortest loop (F) is about 900 ft. The telpher machines on any one of the loops can serve 20 cars. One thousand tons of freight per day can easily be handled by this installation.

There would be times when only one machine would be required on the short loop, and other times when three machines could be operated to advantage on any of the longer loops. Means for transferring the machines from one loop to another can easily be provided near one end of the freight shed. This would consist of a transfer table or cross-overs, which would be used for the sole purpose of transferring machines from one loop to the other. During the normal operation of the machines, each loop would be a single continuous track. There would not be a switch involved in the operation of the system.

Nearly every square foot of floor surface in the freight shed would be covered by the telpher runways, which, in the case of inbound freight, would allow the contents of cars to be distributed and tiered over the entire floor space. In the case of outbound freight, flatboards or trucks consigned to some particular car would be located under the proper telpher runway tributary to the railroad cars to which the load was consigned, and the only hand trucking involved would be in moving the freight between drays and flatboards. This movement would be mostly across the freight shed. A driveway on both sides doubles the available team space. Each telpher could handle two separate loads in making a single round trip of one of the loops—that is, it could bring a load of inbound freight from cars to inbound house, and return a load of outbound freight to the cars. This in itself is of evident value in securing maximum efficiency and capacity.

In planning the arrangement shown by Fig. 1, the object has been to confine each telpher or set of telphers to some predetermined fixed path in making each round trip between the freight shed and the railroad cars, in order to reduce to a minimum the amount of interference possible. All switches have been eliminated so far as the operation is concerned, and the path for each set of telphers has been made sufficiently long so that at least two or three machines can be operated on each closed loop without interference. Having no switches eliminates a great deal of machinery more or less liable to maintenance and repairs, and does away with danger from running into an open switch. One or more spare tracks could readily be provided at convenient points to which disabled or idle machines could be transferred.

While this plan is not intended for transfer work, yet it is possible to handle some transfer freight in the same station by reserving a small portion of the freight shed for the purpose of sorting out the freight. All of the transfer freight would be brought from the cars to this part of the shed, sorted out, and returned to the proper car, being handled in exactly the same manner as the inbound and outbound freight.

The present terminal costs of L. C. L. freight average about 40 cts. per ton for outbound and 35 cts. per ton for inbound freight. Trucking is the largest item of this cost. The system just described proposes to eliminate all hand trucking from a point just beyond the scales to the car door; the cost of transporting freight on flatboards from freighthouse to car door or vice versa will not exceed 3 cts. per ton for power and wages of telpherman.

Transfer Stations.

In a transfer station for L. C. L. freight where the contents of any one car must be distributed to a number of other cars, investigation shows conclusively that it is not possible to obtain an average load of anything like 1,000 lbs. from any one car to go to any other one car. Therefore, to increase the unit movement let us consider a Sorting Platform, a "clearing house" for all freight, *as a part of a mechanical system* for moving the freight where the man with the hand truck is practically eliminated.

For the present, no saving can be made in taking the freight out of cars, or putting it into cars. In order to make sufficient saving in the cost of moving freight, it is necessary for each telpher or unit to carry an average load of at least 1,000 lbs. or more, and 2,000 lbs. would be better. Car-to-car transfer may be accomplished, through the medium of the sorting platform in conjunction with mechanical transportation, at a minimum cost per ton, showing a great saving over present methods.

Let us for example assume a transfer station consisting of six parallel railroad tracks 1,000 ft. long, containing 150 cars, with platforms between the tracks, as shown in Fig. 2. Each of the six runways marked 'A' and the six marked 'B' is an elevated telpher runway about 500 ft. long over the platform and between the railroad tracks. All of these runways terminate at a central elevated Sorting Platform. Over the sorting platform is an ordinary traveling crane carrying a section of telpher track which will span any one of the gaps between A and B. This crane provides a means for transferring telphers from any runway to any other runway, and also can assist in transferring trucks and freight across the sorting platform.

On each one of the 12 telpher runways, a single telpher unit will operate. Therefore there can be absolutely no interference, and owing to the fact that the track has no curves, switches or turnouts the telpher can operate at maximum speed and efficiency at all times. This telpher unit may be a single telpher or several telphers forming a train and operating as one.

As each car is unloaded, the freight is put onto four-wheel trucks or flatboard carriers just outside the car door and underneath the telpher runway. It is immaterial whether the telpher trucks are loaded inside the car and then pushed

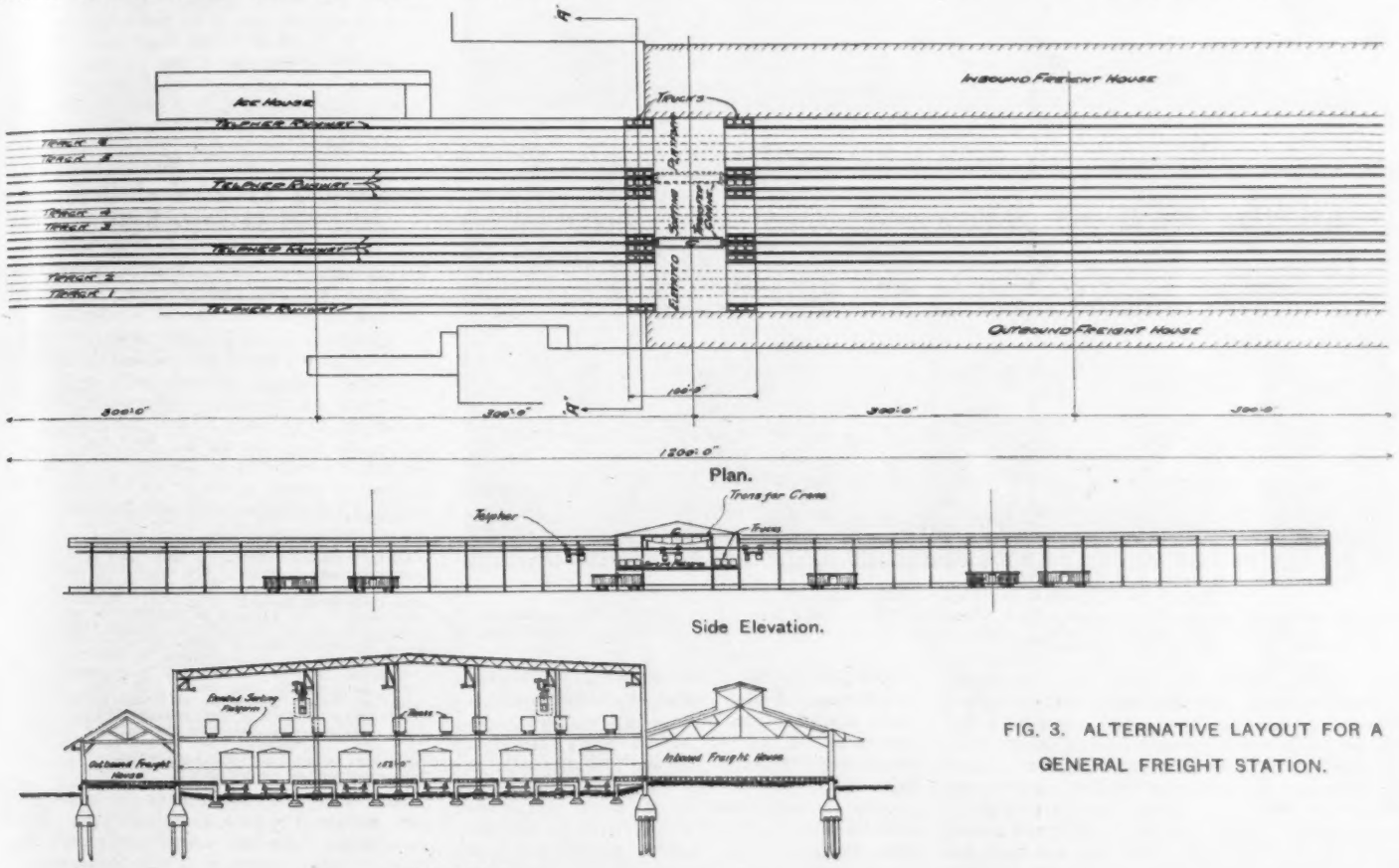


FIG. 3. ALTERNATIVE LAYOUT FOR A GENERAL FREIGHT STATION.

out by hand, or whether the freight is taken out of the car and loaded onto them. The telpher trucks are loaded to their capacity, say 2,000 lbs., if possible, with freight all for one destination. The telpher hoists the loaded truck and transports it to the sorting platform. If the load is all for one destination, the truck is pushed by hand or transferred by the crane across the sorting platform and left at the proper point where one of the other telphers can pick it up and leave it in front of the proper car door. If, however, the truck has a miscellaneous load, it must be sorted by hand on the sorting platform and each piece deposited on a telpher truck on which a load is being made up for some one car or group of cars adjacent to one of the other telpher runways. When one of these trucks has accumulated sufficient load, it is transported to its proper destination by one of the telphers on its return trip from the sorting platform.

No doubt considerable judgment can be used by the men in unloading the cars and in loading up the telpher trucks so as to reduce the sorting on the elevated sorting platform to a minimum. Supervision of a few intelligent men to direct the movement of packages, check the receipt and delivery to cars, and oversee the men on the sorting platform, will no doubt result in minimum breakage and in rapid and efficient sorting and checking of packages. It will then be possible to handle loads of sufficient size so that the use of machinery for handling them will not only result in a great saving but also in greater despatch and regularity, besides increasing the capacity of the station and relieving congestion.

A somewhat different arrangement of cars and platforms, which may possess some advantages, is shown in Fig. 3. The railroad tracks are grouped in pairs, with wide platform between, permitting of four telpher runways over each wide platform and one telpher runway over each narrow platform along the freighthouses. Twenty telpher runways, 10 over each half of the yard, all terminate on the sorting platform. A single telpher operates on each of the 20 runways, and thus there is no possible chance of interference. The advantage of this arrangement of cars and platforms is that greater capacity can be secured, and that as many as eight telphers can be concentrated on any one string of 30 cars for rapid loading or unloading. The wide platform between cars gives greater freedom for moving about.

In addition to transfer freight, inbound and outbound can also be handled to advantage at the same time by passing through the sorting platform.

A capacity of 2,000 tons per day of ten hours can easily be reached by this system, whereas 1,000 tons a day handled by means of handtrucks taxes the present station of the same number of cars to its limit.

The location of an elevated sorting platform in the center of the field of operation reduces the average haul of all freight to a minimum, and to a definite distance, which allows us to calculate with reasonable accuracy the actual cost of transferring the freight. In this case the average haul is 250 ft. from cars to sorting platform, and 250 ft. from sorting platform to cars, or a total average distance of 500 ft. which all freight must be moved. The actual movement of freight from car to car can be accomplished for not more than 4 cts. per ton for power and wages of telpherman. This does not include taking the freight out of cars and putting on flatboards, or stowing in cars from flatboards, nor the cost of sorting on the platform. The total of these three items is estimated conservatively at 15 cts., making the total cost of handling about 19 cts. as against a present cost of 35 cts.

THE USE OF TELPHERS FOR FREIGHT-HANDLING.—The proposal to use telphers in freighthouse service contains nothing novel, as these machines are well known and well tried, having stood the test of ten years' service in many large industrial works. To illustrate the foregoing discussion, however, a view of a form of telpher well suited to the work of handling miscellaneous freight is shown herewith, in Fig. 4. Some features of the machine which bear on its serviceability in the freighthouse will be covered by a brief description.

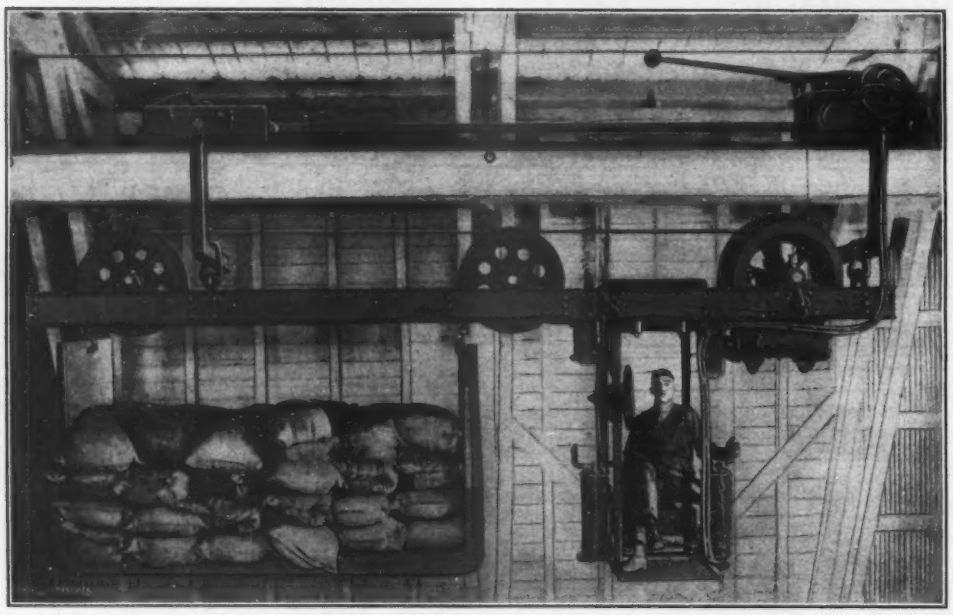


FIG. 4. A TELPHER SUITABLE FOR FREIGHTHOUSE SERVICE.

(A modified form has been designed, with longitudinal hoist-drums mounted on a single shaft worm-geared to the motor, and with controllers located inside the cage. An I-beam is better than the wooden beam in the above view for supporting the track-rail.)

A structural-steel frame carrying a twin-hook electric hoist and a cage for the operator is suspended from the two wheel-trucks by means of forged shackles hung from downcomes, these latter being pivoted to the trolley trucks. The construction gives a flexible connection of the several parts, such as to allow freedom of motion around curves, even balance of loads, and freedom of strains from sudden starting or stopping or sidewise pull of the hoisting ropes.

The machine is designed for traveling on the top of a monorail track consisting of a T-rail mounted on top of an I-beam. Such a track lends itself to smoother running and higher speeds than can be maintained when traveling on the lower flange of an I-beam. Since traveling is the principal duty of the freight-handling telpher, the traveling mechanism should receive special attention in design; the top-rail construction employed gives the simplest and most substantial machine, with the least number of moving parts.

One of the trolley trucks is motor-driven, while the other is a trailer; they are linked together by a drawbar. The truck frames are steel castings, the wheels are of manganese-steel, are double flanged, and are keyed to shafts turning in bronze-bushed axle-boxes provided with oil wells. The motor truck has a cut cast-steel gear on each axle; the motor pinion meshing with both is of chrome-nickel-steel. The motor is fully inclosed. A mechanical brake is provided, with hand-wheel or pedal in the operator's cage to actuate it.

A special design for a freighthouse telpher has been made by the J. M. Dodge Co. (with which the writer is connected), this design being a slight modification of the one represented by the telpher of Fig. 4. The preceding descriptive remarks apply to both machines, but in the new design the hoist drums are placed longitudinally and are mounted on a single shaft which the hoist motor drives through the worm gearing. The arrangement of the operator's cage is also somewhat changed, bringing the two controllers inside the line of the framework, where they are better protected. The conductor wires are preferably strung alongside the web of the track I-beam, instead of overhead as in Fig 4. The general dimensions of the freighthouse telpher are: Length between hooks, 7 ft.; height from hooks to top rail, in highest position of hooks, 6 ft.; height from bottom of cage to rail, 8 ft. 2 ins.; total clearance height, 9 ft. 10 ins.; side clearances from center line, 2 ft. 8 ins. and 8 ins. at the track-beam; width across cage and hoist motor, 2 ft. 4½ ins.; 2 ft. 9 ins.; length c. to c. trucks, 10 ft.; length over all, 14 ft. 3 ins.

Comparative Radiation of Heat Through Solid and Air-Space Boiler Settings

In the course of studies made by the U. S. Geological Survey of the combustion of fuels, the important side problem of dissipation of heat through the walls and roof of a boiler setting was investigated to make the basic investigations more reliable. Data were collected on the temperature gradients through solid and air space walls and on the heat conductivity of the wall materials. These data formed the basis for calculating the heat dissipated. The results of these studies, as reported in Bulletin 8 of the U. S. Bureau of Mines, which at its formation took up the fuel investigations of the Geological Survey, are expressed as follows:

In furnace construction a solid wall is a better heat insulator than a wall of the same total thickness containing an air space. This statement is particularly true if the air space is close to the furnace side of the wall, and if the furnace is operated at high temperatures. If it is desirable in furnace construction to build the walls in two parts, so as to prevent cracks being formed by the expansion of the brick work on the furnace side of the walls, it is preferable to fill the space between the two walls with some "solid" (not firm, but loose) insulating material. Any such easily obtainable materials as ash, crushed brick, or sand offer higher resistance to heat flow through the walls than an air space. Furthermore, any such loose material by its plasticity reduces air leakage, which is an important feature deserving consideration.

This is in contradiction to the general belief that, as air is a poor heat conductor, air spaces in furnace walls will prevent or reduce dissipation. In explanation, it is said that air conducts heat very slowly, but that heat is radiated from a hot body through air very readily. The quantity of heat that passes through the solid part of a wall (by conduction) depends on the difference in temperatures between the hotter and cooler portions, while the heat that passes through the air space (by radiation) depends on the difference between the fourth powers of the absolute temperatures of the surfaces surrounding the air space.

A 30-TON PORTABLE COMPRESSION TESTING MACHINE, particularly adapted for the testing of concrete on the job, has been put on the market by the Watson-Stillman Co., of New York. The machine is merely a hydraulic press, covering a floor area of about 12 × 16 ins. and standing 27 ins. high. It weighs about 425 lbs. so that it may be easily carried from one piece of work to another and set up for the testing of concrete cubes while the work is in progress. The platen faces are 8 ins. square and have a variable opening from 4 to 8 ins. This, it will be noted, gives from a pressure of 940 lbs. per sq. in. for 8-in. cubes up to 3,750 lbs. per sq. in. for 4-in. cubes. The operator applies the load by one of two levers, depending on the amount required, and can at the same time watch the specimen and the pressure gage.

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In the admirable review of engineering education made by Prof. Geo. F. Swain in his Union College address a year ago,* reference was made to the lack of supervision of the work done in our colleges. Said Prof. Swain:

> In many of our institutions there seems to be little or no attempt made to appoint teachers with reference to their teaching ability or to subsequently exercise any oversight over the conduct of their classes or the methods which they use * * * Academic freedom is too often interpreted to mean the freedom of teachers to do as they please, entirely without criticism from any one. * * * Until responsibility can be concentrated and until means and methods are under practical control of the persons so made responsible, there will be no hope of obtaining the highest efficiency in education.

In December last, Mr. Morris L. Cooke, M. Am. Soc. M. E., made a report to the Carnegie Foundation for the Advancement of Teaching on "Academic and Industrial Efficiency" in which he gave the results of investigations he had made upon the efficiency of the Physics Departments in eight leading American colleges and universities. One of the important facts developed by Mr. Cooke was that there was very little executive supervision of the teaching force, or for that matter of the conduct of the whole educational plant. Our colleges and universities have grown like mushrooms; and methods which were followed forty years ago have often been retained from pure inertia.

Now comes Mr. W. D. Taylor, in the present issue of Engineering News with an even more definite arraignment of the colleges for their failure to organize on lines of business efficiency. After reciting individual instances of incompetence and bad work in certain colleges, Mr. Taylor declares that the fault lies not in the men but in the system. "Checking, supervision and inspection" are necessary to efficient work, says Mr. Taylor, and he contrasts the organization of our railway corporations with that of our colleges, much to the detriment of the latter.

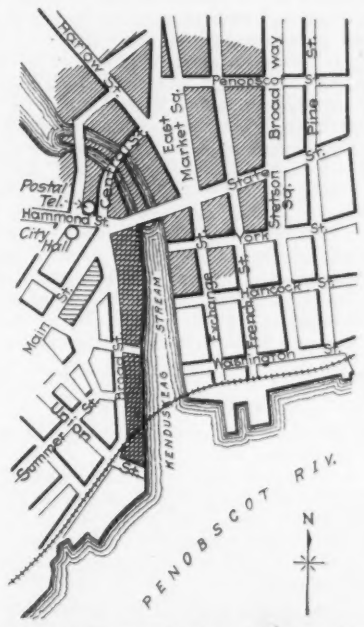
Inasmuch as Mr. Taylor has had wide experience, both as a railway officer and as a teacher, his paper is deserving of especial attention. Our systems of higher education are under a severe fire of criticism, and facts in support of these criticisms are unfortunately only too abundant. In the era through which we have been passing, a college president's success has often been gaged largely by his ability to secure contributions from wealthy benefactors, and the real business of administration has been too often lost sight of. Mr. Cooke's investigation showed that some colleges which were appealing for funds to erect additional buildings were making very inefficient use of the buildings which they already had. Undoubtedly, as Prof. Swain pointed out last year, we shall never be able to gage efficiency in educational work as we do efficiency in production in a factory; but we can at least reform our educational system so that it shall be a system and not a mere aggregation.

We happen to know of a small college whose president and trustees do supervise the work of the professors, do advise them as to methods of teaching and do get rid of incompetents. Some way must be found by which our larger institutions can accomplish the same result.

*Engineering News, May 12, 1910, p. 548.

If it had heeded the warning given more than three years ago by the National Board of Fire Underwriters, the city of Bangor, Me., might have averted the conflagration which visited it on April 30. The map of the burned district, reproduced herewith, shows also the section designated as conflagration breeding in the National Board's report of October, 1907.

The fire of April 30, 1911, started near the south end of this condemned section, which it appears was occupied in part by coal and lumber yards, hay sheds and the like. Helped by a strong southerly wind, the flames swept quickly



Map of Burned District of Bangor, Me.

(Burned district shown by diagonal hatching. Horizontal hatching shows section designated as "bad blocks" in the October, 1907, report of the National Board of Fire Underwriters. Fire started near the corner of Broad and Union Sts.)

through the long, narrow block of mercantile, wholesale and office buildings, all of combustible construction, lying along the west bank of the Kenduskeag Stream and even jumped the stream to ravage the retail and business district just beyond the east bank. The efforts of the fire department were futile, and it was only a change of wind accompanied by a shower of rain that eventually checked the spread of the fire to the north and east through the finest residential portion of the city.

The district where the conflagration hazard was greatest was pointed out most accurately by the National Board in its report, and it explained, moreover, the nature of the danger and made detailed recommendations as to the most suitable means of averting it. Bangor, however, was a typical American town—typical, that is, in its attitude toward fire risks. "Building laws few and of little value. Supervision slight." Thus it was put in the Board's report.

Bangor is already planning to rebuild. She has set a good example in refusing aid from other cities, because, she says, it is not needed. She will do well to add to this display of courage and self-reliance the wisdom to improve her opportunity and build, if not a fireproof, at least a conflagration-proof city.

The work on the Culebra Cut of the Panama Canal during the month of March, not only broke all previous records for quantity of monthly output, as already announced (2,032,523 cu. yds. being excavated on the division), but established a new and very notable low record for unit costs. There are so many items of cost in connection with the work which are fixed and do not vary with the output, that a large output results, of course, in a low unit cost.

The total cost per cubic yard excavated on the Central Division for the month of March for direct expenditures was 37.65 cts. Adding to this the charges for general administrative expenses and the arbitrary allowance of 13 cts. per cubic yard for the plant in use, a total cost of 51.08 cts. per cubic yard is obtained.

In considering this cost record it should be remembered that over 70% of the material handled is solid rock requiring blasting, that the material has to be hauled some twelve miles and disposed of on dumps, that the work is carried on at a distance of some 2,000 miles from the base of supplies, that the white foremen and skilled workmen are paid at rates far above those ruling in the United States and the native labor paid in silver is not of high efficiency, while all labor works short hours, and is more or less limited in output by the tropical conditions. Were it not for other compensating advantages, many of which were not fully appreciated when the canal was projected and the original estimates were made, no such low scale of cost would be possible. As it is the record is one of which the engineers in responsible charge of the work may well be proud.

It may be added that the records for average daily output per steam shovel at work were higher in February and March than in any previous months since the work began. The 50 steam shovels actually working averaged 1,430 cu. yds. output per day.

We presume there are still readers of Engineering News who believe that the Panama Canal ought to have been built at sea level, notwithstanding all that has been published in these columns upon that subject. To such readers we particularly commend the article on another page of this issue giving the personal opinions of members of the American Institute of Mining Engineers who visited the Panama Canal work last November. We have taken space for only brief abstracts from these published opinions, which fill 84 pages of the Institute's "Bulletin" for January. We advise any who are unconvinced by these abstracts to obtain and read the complete report.

A particularly noticeable thing in these opinions is the very considerable number of the members who started on the excursion for the Isthmus in full belief that the sea-level plan ought to have been adopted at Panama, and who were only convinced by their own observations of actual conditions on the canal that the sea-level plan would have been an enormous—and enormously expensive—mistake.

The elaborate and complete statements of the reasons why the lock canal is preferable which have been published in this journal and elsewhere ought indeed to have been sufficient to convince any fair-minded engineer, with enough experience in construction engineering to be qualified to form an opinion on the subject. Those who have found such arguments unconvincing, however, ought to be impressed by the great number of engineers, including not a few members of official commissions, who have gone to the Isthmus prejudiced in favor of the sea-

level plan and have been completely converted by study of the project on the ground.

It may seem like thrashing over old straw or reviving dead issues to bring up again this question as to the type of canal to be built at Panama, since the lock canal is now approaching completion, and all public protests against it from "eminent engineers" or any other class of engineers have died away.

It is, however, barely two years ago that the public prints were filled with sea-level canal propaganda; that the engineers in charge and the engineers responsible for the adoption of the lock plan were being publicly assailed as incompetent; that all sorts of crazy schemes and half-baked inventions were being exploited for building the canal; that the New York "Herald" was acting as a publicity organ for the "eminent" Bunau-Varilla, with his scheme for digging the Culebra Cut with Lobnitz chisels to create his much-advertised Straits of Panama; and that the "Sun," and even the Institute of Mining Engineers, were giving publicity to Granger, with his patent tunneling machine and pipe line scheme of digging a sea-level canal.

All this publicity undoubtedly had its effect in unsettling public confidence and causing the public and the engineering profession to discredit the work and the workers at Panama.

The visit of the American Institute of Mining Engineers and the more recent visit of the American Society of Civil Engineers, with the large number of engineers and men prominent in public life who have visited Panama recently and come back with glowing praise of what they found there, ought to have the valuable result of making the American nation proud of the work which is being done and well done at Panama.

One of the most interesting and important pieces of tunnel work ever undertaken in the United States is to be put under contract shortly in New York City. The bids are to be opened on May 16. We refer to the deep tunnel in the rock underlying Greater New York, which is to distribute the new Catskill water-supply to the several boroughs of the greater city.

As described elsewhere in this issue, this tunnel is to be built in lieu of the ordinary plan of steel or cast-iron distribution mains laid near the surface. The crucial point in connection with this tunnel is the question of its drainage. A great amount of work has been done in making borings along its proposed route and in geological studies and investigation; but about the best that can be said is that it is hoped that the tunnel will be through solid rock, comparatively free from water-bearing strata. That a considerable amount of water will be encountered in the driving of the tunnel, however, is evidenced by the number of artesian wells existing in Manhattan and Brooklyn. The successful driving of the tunnel will depend upon pumping the water out faster than it comes in. The tunnel is at so great a depth that the use of compressed air in its driving will not be possible. The work of draining the tunnel is rendered more difficult, of course, by its great depth, which adds to the power necessary for hoisting the water.

If steam power had to be relied upon for keeping the tunnel drained, its construction would seem like a more or less doubtful venture. Fortunately, however, electrical power is now available for pumping and the enormous energy of the electric power stations in New York City can be drawn upon to supply an unlimited amount of current. This makes it possible to sink the shafts and to drive the tunnel without any of the ordinary difficulties in carrying steam and exhaust piping into and out of the shaft. The only pipe line necessary will be the discharge pipe line, and the current can be conveyed down the shafts by insulated and well-armored wires. Under these conditions it will be possible to take care of an enormous flow of water into the tunnel.

That it is still within the possibilities that some enormous vein of underground water may be encountered, beyond the power of the pumps to cope with, will no doubt be admitted. But by keeping the tunnel lined well up toward the working face and by carrying a drill hole well in advance of the headings to pierce and draw off underground veins of water before they can flood the tunnel, the enterprise becomes comparatively safe to undertake.

The risk involved in the enterprise in case a flow of water should be encountered beyond all possibility of handling with pumps, will inevitably fall upon the city. The contractor may indeed be mulcted to the extent of his financial ability, but it is manifest that no contractor could recoup the city for the loss that would be sustained in case the great tunnel enterprise should be carried part way through and then prove impossible of completion.

The McGrath bill for licensing engineers, which was introduced in the New York Legislature through the agency of the "Technical League," has been amended in several important respects, so that it applies now only to civil engineers engaged on public works in the State of New York. It therefore practically duplicates the examinations required under the State Civil Service law; but such duplication, of course, means an additional tax on the time and the money of engineers in the State employ.

We print elsewhere in this issue a letter from the President of the "Technical League" defending this bill, which is of considerable interest since it has not heretofore appeared what the forces were behind this proposed legislation.

The arguments against any legislation requiring engineers to be examined and licensed have been so fully set forth in previous issues of Engineering News that it is unnecessary to take space to repeat them here.

While the "Technical League" is the avowed author of this engineers' license bill, it is suspected that the real force behind this legislation is represented by certain engineers who are looking forward to appointments on the proposed State examining and licensing board, and to the practical dictatorship over the profession which they would thus secure. It is true the present bill would give them control only of the engineers engaged on public works; but if the McGrath bill were passed this year, a Hoff bill embracing the whole engineering profession might be enacted next year. In our opinion the time to keep the camel out of the tent is before he gets his head inside.

Of all the fraudulent concerns operating to despoil the unwary, about the meanest are those which seek to get hold of the savings of the man who is out of a job and looking for a position. It has come to our knowledge that some of the engineers advertising for positions in our columns have received letters reading substantially as follows:

> We are now increasing our force and require all our engineers to be interested in the company, which ought to pay handsomely for the money invested. If an investment of this kind, with services included, will interest you we would be pleased to hear from you further.

The scheme which the company sending out this letter has in hand, was evident on its face to any one of experience to be a quixotic enterprise, absolutely impossible to finance; yet it was one which might well deceive some young and inexperienced engineer. Inquiries as to the financial standing of the concern showed that it was not even incorporated. Those in the office expressed the intention of obtaining a charter from the State of Arizona. The names of those who were connected officially, or were to be connected, with the company were declined to our representative.

We call attention to this because it is a sample of the traps which are laid—in too many cases, we fear, successfully—to dupe the engineer who is out of a position and separate him from his hard-earned savings. It is safe to say that no proposition of employment involving investment in a new concern should ever be considered by an engineer, unless he is well acquainted personally with the principals in the business and knows them to be absolutely honest and reliable and to be financially and technically competent.

The Slides on the Panama Canal.

Public interest has been excited during recent months by repeated newspaper reports concerning the development of slides on the banks of the Culebra Cut on the Panama Canal. Many questions are asked concerning the importance of these slides, concerning their cause, concerning their probable effect in increasing the cost of the canal or delaying the time of its completion. It has seemed worth while, therefore, to present a report of the facts.

As most engineers know, trouble with slides on the canal began during the early days of the French excavation under de Lesseps. The earth on the slopes of the Isthmian hills is a reddish clay, which is very greasy and slippery when saturated, as it constantly is during the wet season. For a third or more of the nine-mile length of Culebra Cut, the hills slope steeply toward the valley along the bottom of which the canal is located. When the toe of these slopes was removed by the excavation, the city was left in condition to slide whenever and wherever the friction between different layers or the friction of the whole mass on the underlying rock became low enough.

These slides in the clay slopes above the canal cutting gave much anxiety to the French engineers, as well they might, considering that the task which they had set for themselves was the cutting of a sea-level canal through the continental divide. Charles de Lesseps is said to have sent word to his father at one time that the mountains along the line of the canal were moving toward it and were likely to close up the cut as fast as it was dug.

One of the standard methods of dealing with sliding earth slopes is to provide a system of drains to carry off the rainwater and prevent its saturating the earth and lubricating the sloping surface on which the material rests. The French engineers made thorough trial of the drainage system at Culebra. They built an elaborate system of concrete surface drains to collect and carry off the rain water, some of them of large size. This elaborate drainage system, however, had no effect in retarding the slides.

It is impossible in this country of heavy rainfall to prevent saturation of the earth on these slopes. During the dry season the top layer of earth dries out and shrinks and a labyrinth of broad deep cracks is formed, a phenomenon familiar to any one who has ever experienced a long drought in a clay country. When the rainy season comes, these deep cracks catch the water and permit it to soak down deep and saturate the underlying earth. The orthodox plan of surface drainage to prevent the sliding of earth on steep slopes will not work in such a country.

The Americans resumed work upon the Culebra Cut in 1904, and by 1907 the excavation assumed large proportions. The conditions of stability, which had been established during the 15 years while excavation was suspended, were upset and the banks again began to slide. Since 1907, the slides in the cut have been repeated sources of danger and the material sliding into the canal prism has added materially to the amount of excavation.

During the year ending July 1, 1910, no less than 15% of the material taken out of Culebra Cut was removed from slides. For the past year and a half, the slides have been more numerous and the material moving down into the cut, with the evidence of more to come, has been much more serious than during any previous period.

Up to the middle of 1909 nearly all the slides were due to the top layer of clay on the slopes moving down into the cut. Since that time breaks have occurred in the rock strata, at various points; and most serious of all, the bottom of the canal excavation has been forced upward in places by the lateral pressure, a phenomenon almost unprecedented in engineering records.

It should be said, however, that these slides affect only a small part of the length of the Culebra Cut. Of the total distance of nine miles it is probable that the banks on not more than one-fourth to one-third the length shows any tendency to slide, and the really serious slides form a much smaller fraction of the total length.

FIG. 1. VIEW OF CUCARACHA SLIDE FROM TOP OF CONTRACTOR'S HILL, OCT. 23, 1910.

(The slide had moved forward, dammed the central drainage ditch and flooded a steam shovel working on a low level. It had also wrecked a dirt train, and had partially buried the steam shovel which was loading it, and blocked all the tracks on one side of the center.)

A brief summary of the slides was prepared on March 9 for the members of the American Society of Civil Engineers, who went through the cut during their visit to the canal works in March.

According to that summary, there are now in Culebra Cut thirteen good sized slides and nine smaller ones.

The largest of these slides in area is the great Cucaracha (Cockroach) slide, which started in 1884, soon after the French began working on the canal. The total area of surface in motion on this slide is about 47 acres and the break at the back of the slide is 1,820 ft. distant from the center line of the canal. At eight different times since the American work began, this slide has moved forward till its front reached the center of the canal prism, and several times it has moved across and closed temporarily the drainage channel in the center. Over 2,000,000 cu. yds. have been taken out of this slide since the American work began, and the slide is still moving and the steam shovels are still digging away at its front.

The highest elevations along Culebra Cut are at Gold Hill and Contractors' Hill. The rock of these hills, which is partially of trap, has never shown any tendency to slide, but the most serious slides on the cut occur directly adjacent to these hills. It is conjectured that the heat of the eruptive material forced up in the formation of these hills weakened the stratified rocks on either side and rendered them liable to fracture and slip.

Be this as it may, the fact is that just north of Gold Hill there are enormous slides on both banks of the cut. On the side next Gold Hill is a slide which started two years ago and has been increasing and extending farther backward ever since. On Feb. 9, 1911, a break occurred which extended the back of this slide to a distance of 1,200 ft. from the center line of the canal, and increased its area to 17 acres.

On the opposite bank of the cut, at Culebra village, is a slide which now covers an area of about 18 acres. The total width of Culebra Cut at this point, from back to back of the slides at the top, is 1,950 ft. This is not the end either, for the earth has cracked and moved for a considerable distance farther back.

From these two slides about 3,000,000 cu. yds. have been removed, and it is estimated that over 2,000,000 cu. yds. are still in motion.

These are the biggest of the slides. The others are all small in comparison, although large in the aggregate and likely to be much larger before they finally become quiescent.

The slides at Culebra are particularly serious not only because of the amount of material involved, but because part of the village of Culebra, where the canal headquarters are located, is threatened. Already some of the houses nearest the cut have been taken down and moved, and it is expected that a number of others will have to go through the same process to save them. The large clubhouse at Culebra has moved several inches down the hill, and a crack has opened in the earth beneath it.

A good idea of the smaller slides is given by the accompanying photograph of the slide which took place in December last opposite Las Cascadas. This slide began motion in August, 1908, but was for a time of comparatively small proportions. In the movement last December, the break extended to a distance of 750 ft. back from the center line of the canal and eight acres of moving earth and rock were involved. As shown in the photograph, a huge mass of earth and rock flowed forward like a glacier clear to the central drainage ditch. Over 200,000 cu. yds. had been removed from this slide in early March and 150,000 cu. yds. was still in motion.

The occurrence of slides in the earth on steep slopes is an exceedingly common thing in engineering construction. The sliding of rock is very much more rare, so much so that engineers have seldom thought it necessary to take it into account in their calculations.

In the deliberations over the type of the canal, for example, it was generally assumed that trouble with slides would be ended when the excavation in the earth was finished and the work was wholly in the rock. It is now clear, however, that the slides have a very important bearing on the question of the type of canal and on the fixing of the most economical summit level.

It is of much interest to study the causes of the breaks and slides which have occurred on the Culebra Cut. It should be understood in the first place that nearly all the rock in Culebra Cut disintegrates when exposed to the air. Furthermore, it is weakened by seams and fractures and is very variable in its strength, some of it being so soft that it can be picked to pieces with the fingers. One of the most prolific causes of slides has been the occurrence of thin seams of lignite, usually only a few inches thick and very weak, friable and slippery.

On the east side of the cut for a considerable distance the dip of the strata is toward the cut, so that wherever a seam of this lignite occurs, the rock above it tends to slide down into the cut on the slippery slope formed by the lignite seam.

The occurrence of slides, here as everywhere, depends on three factors, the strength of the material, the frictional resistance to motion, and the weight and angle of the slope upon which it rests. Every engineer knows how uncertain are coefficients of friction, even in the work of the mechanical engineer, where conditions are most favorable for uniformity. The strength of the

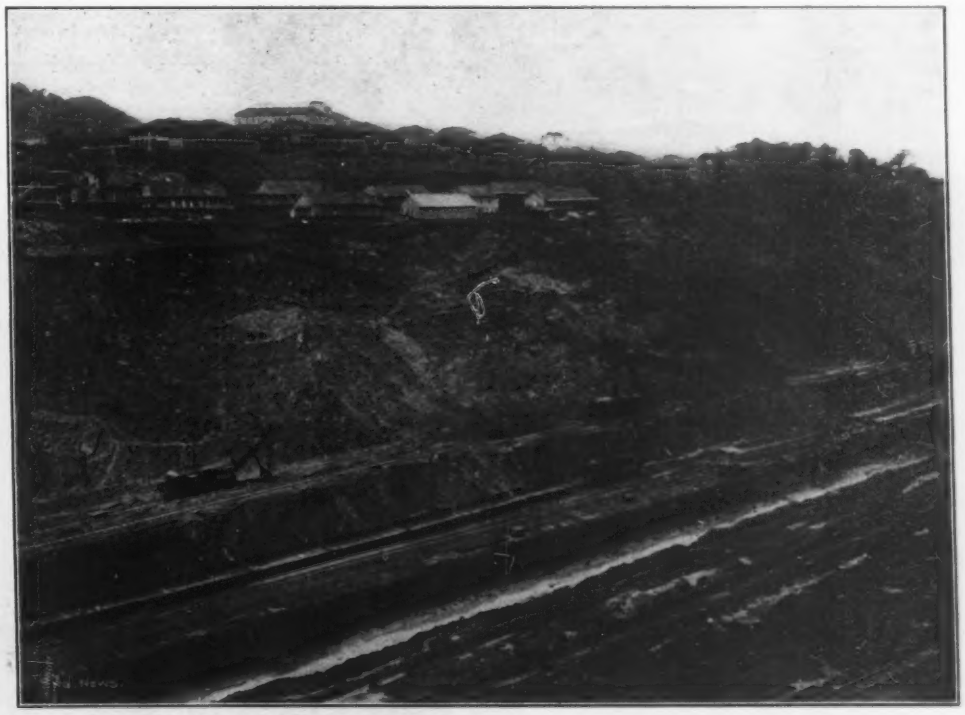


FIG. 2. BREAK IN WEST BANK OF CANAL AT CULEBRA, OCT. 16, 1909.

(While this photograph was taken 18 months ago, it is selected for reproduction because of its sharpness of detail and because it clearly shows the relation of Culebra Village to the breaking bank. Since the view was taken, a number of the buildings near the edge of the bank have been moved away, and the bank has broken back much farther into the hillside. Close inspection of the picture will show how the sliding material has buried the railroad tracks in the foreground and wrecked the track on the upper level.)

FIG. 3. VIEW OF BOTTOM OF CANAL RAISED 18 FT. BY PRESSURE FROM SLIDE ON EAST BANK, NORTH OF GOLD HILL, JUNE, 1910.

(Photograph is taken near center line of canal, looking toward Gold Hill. Besides the prominent hump in the foreground, it may be noticed that both the material trains show a noticeable hump in the tracks. The difficulties in drainage, due to such bulging of the bottom, are evident.)

underlying rock is so extremely uncertain and variable that little can be predicted concerning it. It will be apparent, therefore, that no one, either geologist or engineer, is wise enough to predict when and where slides will occur, nor can very much be hazarded as to their extent and continuance, except from the practical experience already gained with the earth and rock slopes on the Isthmus.

The Canal Commission is flooded with all sorts of proposals from engineers, and people who think themselves engineers, giving advice how to deal with the slides. These proposals run the whole gamut, from mathematics to faith cure, and constitute a veritable museum of curiosities.

Most of these volunteer advisers would perceive their own folly were they to study the slides on the ground. The commonest proposal, perhaps, is to build retaining walls to hold back the slopes. The first essential in building a stable retaining wall, however, is to know, within reasonable limits of accuracy, what the pressure will be against its back. But to compute this pressure we must know the weight of material in motion, the angle of the slope and the coefficient of friction. All these things are unknown, and the latter particularly is subject to enormous variation.

If we add to this the fact that the Culebra rock is most uncertain material on which to found a retaining wall, that a retaining wall, if built, would merely replace a certain amount of natural rock with concrete, and that whenever and wherever a concrete retaining wall should fail it would be many times worse to dispose of than the natural rock, the absurdity of the retaining wall proposition should be manifest.

The most suggestive proof of the impotency of attempting to hold these moving acres of ground in place by any structures man can build is the bulging up of the bottom of the cut which has taken place at certain points. Engineers are familiar with such bulging in soft material. It is not at all uncommon in filling across a swamp, for example, to see the black mud shoved up in ridges parallel with the bank and some distance away.

In the Culebra Cut this bulging of the bottom means that the lateral pressure of the material moving down the slopes is so enormous that it compresses the rock in the bottom of the canal until it is fractured and forced up as a column failing in a compression test is bulged sideways.

Of course, if the cut were made through firm, solid rock, such yielding under compression could not occur; but as already explained, the Culebra rock, though hard enough to require drilling and blasting, is the poorest sort of stuff to place any reliance upon. The bulging of the bottom of the cut shows that there is not only an enormous lateral force from the moving slopes, but a weak, fractured and friable rock in the bottom. It will be evident, however, since even this rock must exert a great resistance against the toe of the slopes, that when the cut is deepened as the work progresses and this rock is all removed, there will be nothing to hold the slopes back and further slides will take place. What their depth and breadth may be, nobody is wise enough to say.

In dealing with the slides, the engineers have done the only thing possible to do, that is to dig out the material as fast as it moves in, or at least try to keep pace with the motion. Of course, when a sudden movement occurs, the slide gets the upper hand and frequently slides have come down so rapidly as to bury steam shovels and wreck trains before they could be moved out of the way. Careful watch is kept on the working face and when stones and pieces of dirt begin to rattle down it is a warning to be ready to move the shovel on short notice. When the slide hangs and threatens to come down suddenly or the face at which the shovel is working becomes dangerously high, something may be done with explosives to start the mass along or break down the face.

Considerable work has been done on some of the slides also to take the pressure off the top by running steam shovel cuts along near the upper part of the slide. It is evidently advantageous to take material out at this elevation where it will be hauled down grade to nearby dumps rather than let it slide down to the bottom of the cut. Further, by reducing the pressure on the slopes, the force causing the slides is reduced.

If all the material sliding down into the cut were earth, it might be good policy to concentrate work in the bottom of the ditch, bring it down to grade as soon as possible and leave the slopes alone. Then, if the water could be brought in to a depth of 15 to 20 ft. any earth which might slide in from the slopes could be removed by dredging at a cost of only 10 to 15 cts. per cu. yd. compared with upwards of 50 cts. per yd. for the present work with steam shovels and trains.

While the larger part of the material in the slides is earth, a good deal of rock is also in motion, and enough solid rock to make its dredging probably very expensive if it were allowed to slide unbroken into the canal prism when filled with water. Again it would not be a safe proceeding to advance the work in the bottom of the cut unduly beyond the work on the slopes. The instability of these slopes, even under present conditions, is thoroughly demonstrated. The work must be so handled, therefore, that the risk to equipment and to the working force will be as small as possible.

It will be at least a year, probably, before work on the locks, lock gates and dams will be advanced far enough to permit filling Lake Gatun to a level sufficient to give a navigable depth through Culebra Cut. About 21,000,000 cu. yds.

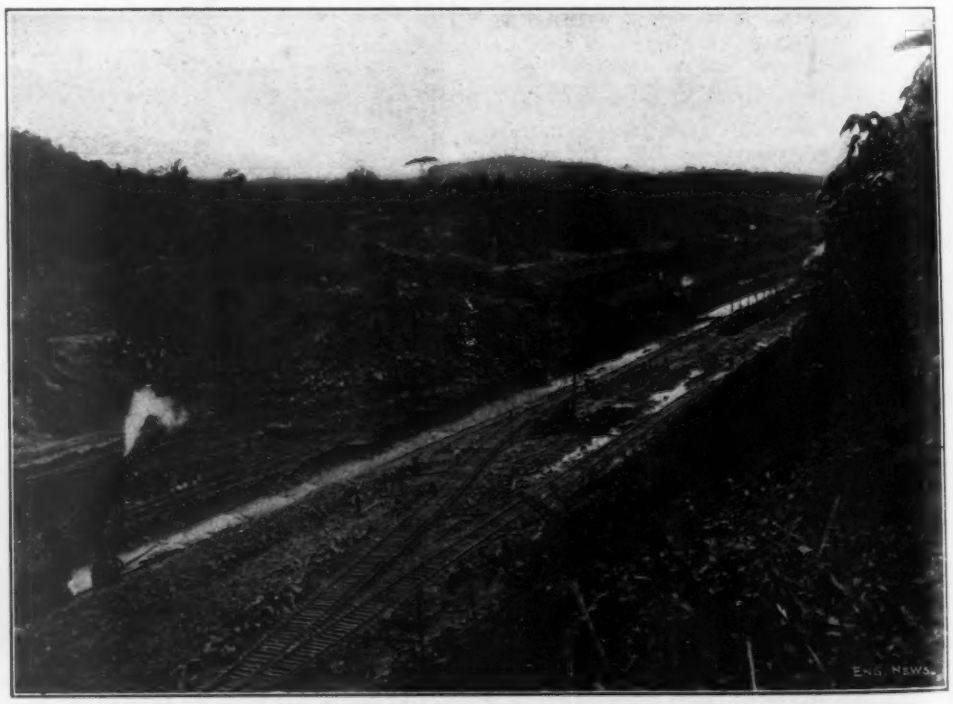


FIG. 4. SLIDE IN EAST BANK OPPOSITE LOS CASCADAS, DEC. 15, 1910.

(Note the amount of rock in the slide and the depth to which all the tracks on one side of the central ditch have been buried. The heavy tropical growth on top of the slide and moving down with it should be instructive to the volunteer who sent an urgent letter to the Commission advising them to at once stick willow cuttings on the slides, which would promptly grow and hold the banks in place!)

remained to be excavated in Culebra Cut on May 1. Probably 12,000,000 to 14,000,000 yds. of this can be removed in the coming year. By the time water can be brought into the cut, therefore, there will be (barring an enormous increase in sliding material) only a small amount left to be done in this section.

It is quite within the possibilities that more or less sliding of the slopes may occur for some years after the canal is opened. The bringing of water into the prism will produce a counter-pressure on the sides and bottom of the canal prism, and since the rock of the cut remains solid when kept submerged, will tend to maintain the banks in place. Such slides as occur then are likely to be chiefly in the earth and disintegrated rock exposed on the slopes.

A very large and powerful ladder dredge is being built in Scotland for the Canal Commission, with the idea that after the construction period is ended it will be useful for maintenance work. As the channel is 300 ft. in clear width, this dredge will be able to remove any sliding material from the prism without interfering with navigation, and doubtless at very moderate expense.

If any engineer remains still unconvinced that a wise choice was made when the lock plan instead of the sea-level plan was adopted for Panama, a study of the slides which have occurred during the past year and of those which may be expected as the prism is further deepened should satisfy him of his error. The members of the American Institute of Mining Engineers and of the American Society of Civil Engineers who have visited the canal work during the past six months agreed that the slides have given the final demonstration as to the folly of the sea level plan.

Along the section where the sliding is most serious, the cut has still to be deepened from 50 to 60 ft. below the present lowest excavation at the center and much more than that at the sides. If the sea-level plan had been adopted, this cut would have to be carried down 85 ft. deeper still, with proportionate increase in excavation on the slopes and proportionate increase in the pressure tending to force these slopes inward and close up the canal prism.

In the estimates for the sea level canal, made in 1905-6, a certain cross-section and certain angle of slope had of course to be assumed. Nobody then knew or could know how unstable and treacherous was the rock in Culebra cut, and it could not be foreseen that as the cut increased in depth, the pressure upon the slopes was likely to become so great as to overcome the resistance of the weak, rotten rock in the canal bottom and actually force it upward Had such conditions been foreseen, the assumed slopes in Culebra cut would have had to be flattened, and the volume of excavation and the estimate of cost, enormously increased.

It is not only in Culebra cut that the slides are giving an object lesson as to what the nation would have been up against had the sea-level plan been adopted. Plenty of other experience has accumulated as to the behavior of the soft material in the Chagres swamps when excavation is carried below water level.

For several months the engineers have been fighting to complete the excavation for the lowest lock of the Gatun flight. The floor of this lock has to be placed about 45 ft. below tide level. The rock in the Gatun hills dips down toward the north, so that the rock surface here is about at the general level of the lock floor. Overlying the rock is an alluvial deposit, some of it exceedingly soft, of about the consistency and general appearance of axle grease.

During a recent visit of a member of the editorial staff of Engineering News to the canal works, he witnessed a slide in motion at the lower end of the Gatun lock pit at the site shown in the accompanying photographs. During the previous week a slide had occurred which started so suddenly that a steam shovel was buried before it could be moved back and two laborers working beside it were caught and killed before they could escape.

Since that time the work had proceeded digging away the toe of the slid material until the resistance was reduced so that the slide again began to move and broke back much farther from the cut than before. A mass of material some 300 ft. long, 50 to 100 ft. wide and 10 to 20 ft. thick flowed slowly but irresistibly down the slope, its front piling up to a height of 6 to 10 ft. as it slowly advanced over railway tracks and embankments. The flow continued for some five minutes with a total advance of 20 to 50 ft., and a face some 20 ft. high was left at the rear where the break occurred, in what had been a smooth grass-covered slope.

While these slides have considerably delayed the work on the lowest Gatun lock and have added somewhat to its cost, they are chiefly instructive as an illustration of the task engineers would have had to face had they been ordered to carry a ditch at that depth, not through the distance of a thousand odd feet required for the lowest lock at Gatun but all through the Chagres valley for the 30 miles from Gatun to the entrance of the Culebra cut.

It is true that a large part of the work would have been done by dredging and the water in the channel would have helped to hold the banks in place; but a good deal of rock excavating would also have been necessary and just such slide-fighting would have been required to lay it dry as that illustrated at Gatun.

Recurring to the slides in the Culebra cut, it may be recalled that a summit level of 100 ft. was advocated by the chief originator of the present plan of construction, Major Cassius M. Gillette. In Engineering News of July 27, 1905, Major Gillette set forth at length a definite plan for a Chagres River Dam at Gatun, a site which had been suggested by Mr. C. D. Ward, M. Am. Soc. C. E. a year earlier in a paper before the American Society of Civil Engineers.

It may be questioned, since the development of these serious slides in the Culebra hills, whether it would not have been advantageous to have given 15 ft. greater height to the Gatun dam and locks and saved 15 ft. depth of excavation in Culebra. It will be possible to answer this question more definitely a year or two hence when it is seen how much additional material moves on the Culebra slopes. At present it would appear that while the raising of the dams at Gatun and Pedro Miguel would offer no difficulty, the increase in lift of the locks, or the making of an additional lock would be a most serious objection to a higher summit level. Besides this, a 100 ft. level in Lake Gatun, would probably require considerable dike construction in low saddles over the divide between the Trinidad valley and the Caribbean. So far as can be seen, at present therefore, the summit level of 85 ft. seems to have been a wise choice.

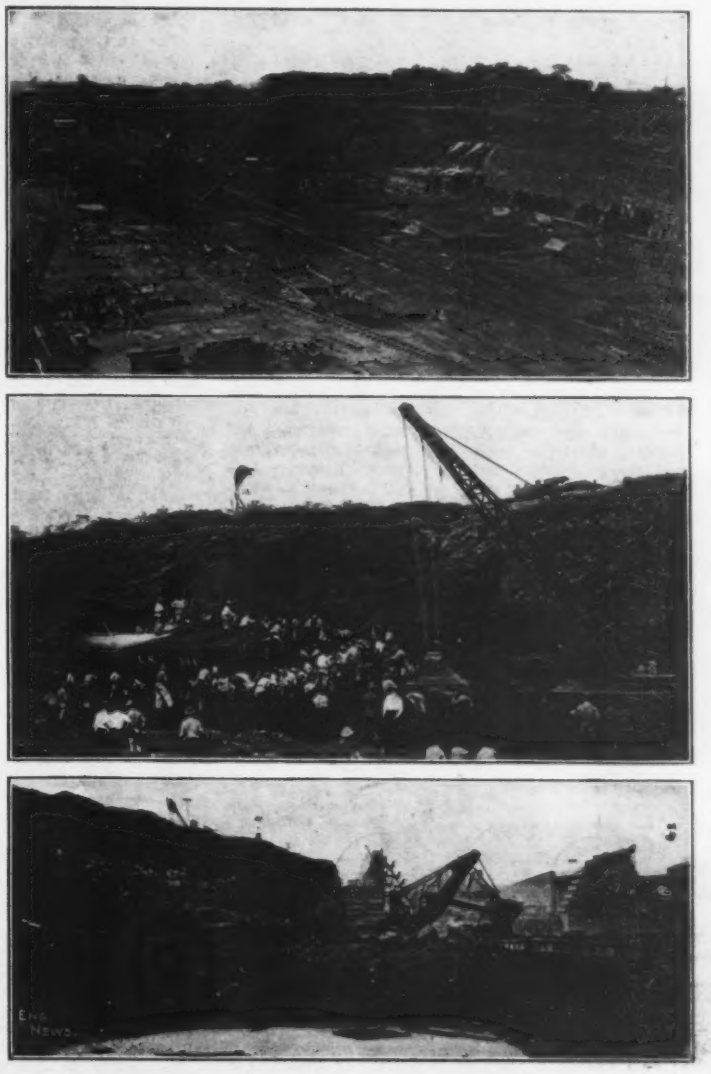


FIG. 5. THREE VIEWS IN THE LOWER LOCK-PIT AT GATUN.

(The upper view shows a general view of the pit, taken March 10, 1911, just after the slide which buried a steam shovel and killed two men. The next view shows a near view of the slide, with a wrecking crane and clam-shell excavator at work digging out the buried steam shovel. An idea of the depth of the pit may be gained from the locomotive on the track above. The lower view shows a slip which occurred at the same point a few weeks earlier.)

LETTERS TO THE EDITOR.

Concerning the Design of a 110-in. Gate-Valve Casing.

Sir: Re the design of the 110-in. gate-valve, I notice in your editorial note following my letter of March 17, inserted in the Engineering News of April 20, that you say, "In considering any curved piece under stress, it is important to remember that an arch is an arch only when it has effective abutments. Without abutments it will act only as a beam." Don't you think in the present case that the two sides of the valve can be taken as abutments? You will notice that these sides go all around the valve without changing in width except at the head of the cap and the bottom of the body. Through their curved shape and their continuous ring-shaped course around the valve I calculated them as effective abutments.

I have made some practical experiments on smaller shapes of this kind and I have found out that the ratio of metal used for a given strain and with equal results in both cases (as between the old, accepted shape of valve and the one under notice) is three to one in favor of the new shape. I have found that an ordinary 6-in. gate-valve built under the old lines for the test pressure of 300 lbs. would break when the test came up to about 800 lbs., and that for the shape in accordance with my design a valve built for 300 lbs. test would stand 1,050 lbs. before breaking. I have seen also that the deflection is much less with this shape than with the older shape. The leaking is less in this case also. In both cases the valve broke at the corners, which appear to be the weakest point.

We are confronted in the practical making of the valve by the fact that we cannot obtain a good casting by reinforcing the corners more than about twice the thickness of the shell. If we exceed that ratio we obtain in the corners a spongy casting that gives prac-

tically no resistance to any strain put upon it. I have worked out some formulas from these experiments and when I have got them in shape I will forward them to you for general information. Hoping to hear through your columns the opinions of some other engineers, I am.

Phil de Clamecy.

Dorchester, Mass., April 29, 1911.

The Inventor of Portland Cement.

Sir: I notice in your issue of April 27, p. 515, a letter relating to the disputed question as to the original inventor of Portland cement. I have gathered a great deal of data on this subject by careful personal search in England, and would call your special attention to an article, in which I have embodied a portion of the data secured, which appeared in the "Cement World," Feb. 15, 1911, p. 24.

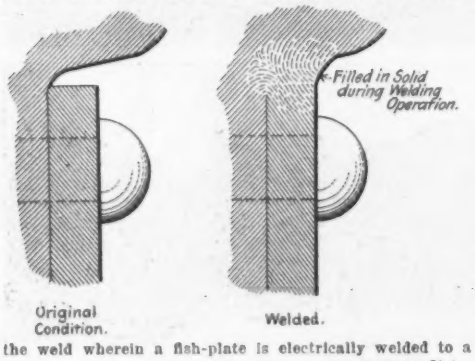
You will note that the date of the original patent given in your account as 1842 should have been 1824, but this is probably a mere typographical error. In the little booklet published a few years ago (1909) by the "Cement Record," of Kansas City, to which you refer, Mr. I. C. Johnson, in his own handwriting and over his own signature, makes specific claim to have been the original inventor. This claim does not comport with Mr. Johnson's written statements published in 1902, from which I have quoted in my article; and it is interesting to note that Mr. Johnson himself has very recently retracted all his claims to have been either the original inventor or the first manufacturer. Were it not for Mr. Johnson's setting forth of these claims, probably the honor which rightfully belongs to Joseph Aspdin would never have been questioned. No one would dispute the fact that Portland cement, as it is now manufactured, has been an evolution; yet the same is true of every other important contribution that has ever been made to technical and scientific progress. And this fact affords no reason why a man who has been dead for 56 years should be stripped of laurels that had crowned him without ever being raised in question for a generation or so after his death.

Alfred Sidney Johnson,
Editor, "Cement World."

Chicago, May 5, 1911.

The Best Way to Show a Weld in Cross-Section.

Sir: Will you kindly explain the proper method of showing, in a cross-section, the difference between the regular and a welded area? A dispute has arisen concerning the proper way of showing the welded area and



the weld wherein a fish-plate is electrically welded to a rail, the weld penetrating the plates approximately ⅝-in.

C. F. Gailor, Roadmaster.

The Connecticut Co., Hartford, Conn., April 1, 1911.

[Our Chief Draftsman, Mr. C. W. Reinhardt, suggests the plan of distinguishing the welded area shown in the accompanying sketch.—Ed.]

Making a Profession of Engineering: The President of the Technical League on License Laws for Engineers.

Sir: Engineering News of March 23, 1911, states editorially that a movement to enact engineering license laws is widely abroad in the different states of this country; that the flood is due to propaganda; that the News editorially "respects sincerely" (we are glad to note it for the first time in its utterances) "the opinions of those engineers—not a few on the whole" (we observe with pleasure that the News is awakening to the fact) "who see good in the proposed Laws."

May we then be permitted to present our views before our Civil Engineering brothers (we have declined from the outset to discuss the matter with any other kind of engineers) from the platform of those who entertain honest, earnest and deeper-growing convictions on the subject.

We wish to interest in the subject that great majority of silent, tireless Civil Engineers both successful and unsuccessful who are too busy to go off "half cock" on grave matters and too proud or self-respecting to rush pell mell to the support of any manipulating or over-hasty managers of their engineering societies, local or national, who, contemptuously rejecting the friendly overtures of a group of investigators of the subject, rushed headlong and ill-prepared into taking a position and attempting a course which they are rapidly discovering to be untenable. A few of these people have descended low enough to indulge in personal insult and invective against the gentlemen urging upon the attention of the public and the "profession" a suggestion which they believe to be for the betterment of both.

Passing them with the silence and contempt they deserve we ask the busy and forgotten civil engineer who does his own thinking to lend us an ear for a few months and then pass judgment on the matter. We ask him to put a word of argument or encouragement on a postal or in print to help elucidate the subject. We believe it will pay him professionally and financially.

Now to the point: Let us refer to the salient points brought out in the discussion in the "News" and elsewhere. Any child knows that the law will apply with more force and be of more value in one state than another. In a highly populous and wealthy state it is more valuable in certain respects than in a new state. More money is spent there upon engineering works and upon the engineering luxuries of civilization. More need of protecting dense communities too. Therefore, the law should be most elaborate there. Other states will imitate and adapt it according to their progress or requirements. New York requires the most elaborate perhaps.

Beginning a movement like this without precedent the first draft of the law was comprehensive and hopeful. It was also crude. But it drew attention to it. Discussion and the usual violent opposition showed how to correct it.

It showed also where selfish interests would step in, as they always do, to prevent the adoption of any clear-cut comprehensive measure.

It proved also what a vast amount of ignorance and narrowness, especially the latter, envelops our great calling. But we have great confidence in their capacity for rapidly adjusting or assimilating new ideas and conditions. Therefore, again to the point. Every change in the bill now before this state for two years and over has been the result of either a convincing argument or a concession to what Gladstone called "expediency" in framing laws, not perfect, ab initio, but to build upon and improve.

That answers the contemptuous "change of front" on our part mentioned at the foot of page 357 of the "News" of March 23.

Many of the features in the original Raldiris and McGrath bills will in years to come be returned to it at the request of the very people who now oppose them.

Some of the advocates of this law are on page 357 referred to as "specialized organizations—one being a trade union of subordinate engineering employees (most of them in the Municipal service)." That is intended to mean but dares not thus name (it is legally indiscreet) the "Technical League." Let it suffice to say in proving the editorialist's reckless or intentional ignorance of his subject and his straining desire to find evil in this measure, that there are but two men alive, its President and its Secretary who know enough about the composition and the identity of the members of that Engineering Society to even hazard a guess.

And in the course of a few months or a year he may have another rather indigestible pill to swallow when its membership list is printed.

The other specialized organization referred to is the "Society of Municipal Engineers" of about 500 members all engaged in the Engineer Service of New York City.

We venture the opinion that if they were suddenly to vacate their positions, the most of the latter would be eagerly sought by members of one or more of our national societies and produce a very perceptible rise in the average income of its distinguished membership—and this is said in no spirit of disrespect, but to show that New York comes nearer to paying her engineers a living wage than many states or corporations and she builds bigger public works.

Again if Engineering News had had in Albany a more alert reporter at the hearings on the Hoff and McGrath bills it would not have been placed in the position of having to be told that the "reason" the advocates of the McGrath bill worded it "so as to apply to Civil Engineers engaged on public works only" instead of being "a puzzling question" was a matter of constitutional law pure and simple, as its advocates very plainly and emphatically explained. Failure to know this was one of the causes of the sudden death of the Hoff bill.

Was the Editor also sincere when he writes as follows on page 358:

> It appears that what is really sought is not the safeguarding or ennobling of the engineering profession, but some form of protection to subordinate engineers in municipal or state service. These employees already have full protection by elaborate civil service provisions, guarded by a great multiplicity of examinations.

If so it were well for him and his Civil Service engineering subscribers that he ask even a child in Civil Service law and learn that there exists not one scrap of legal protection under the state or municipal civil service against removal unless the incumbent be a war veteran or an exempt volunteer fireman.

These last paragraphs in the editorial can only bring a smile of pity at the extreme to which the opponents of licensing are driven for argument when they have to resort to such arguments.

Again we quote:

> Efforts are now being made in some public engineering bureaus of the state to remove part of the civil service protection, and it is charged that this has political aims. This occurrence is not so far out of harmony with the license law agitation as to remove all suspicion that the two may be connected.

The engineering representatives in the City Service have themselves been the most persistent and implacable of the enemies of "exempting" positions under the Civil Service and particularly in the engineering service, and they have carried their opposition into court and before the commissions of the city and state.

Again to the main argument: The Standard Dictionary gives as the primary definition of "Profession": an occupation that properly involves a liberal education or its equivalent and mental rather than manual labor, especially, one of the three so-called learned professions 'religion, law, medicine.' Its secondary definition includes 'callings or occupations' involving special mental and other attainments or special discipline, as acting, editing, engineering, authorship, etc., and its collective followers.

One of our respected but misguided opponents writes that "engineering has been a profession for a thousand years." We refer him to the above. We trust he understands the difference between the primary and secondary definitions of the dictionary. It may be that engineering is in the primary class; but the courts have not so construed it. We propose to help put it there. As engineers both high and low as a group are considered, treated and paid there is no doubt as to their being held to be, in a commercial sense, not much above the level of inferior mechanics.

This fact we greatly deplore and hope in time to remedy.

The Technical League is willing to face and withstand all the obloquy that may be heaped upon it. It does not intend to lie dormant and unproductive as long as some of its older and more noted engineering society rivals and content itself with merely publishing its "Transactions" i. e. the papers (often valuable ones) read before its various meetings or branches.

The League intends first to take up the economic and educational questions which affect the "profession" and discover how it is possible to improve them. We cannot see that it makes the slightest difference, for that purpose, whether its members are all chief engineers or all rodmen. There are enough of both in its membership engaged upon this work of uplift to lead us to believe that we shall evolve something of value by patience, persistence and investigation. And we are rapidly getting valuable hints and helps from some of the really great civil engineers of the country who are evincing so lively an interest that we are not even passingly interested in the empty vaporings of a few who noisily advance nothing but pointless general objections to a license law.

Those connected with the Universities and Technical Schools have extended to us more useful hints than many of their "practical" contemporaries.

The two most insistent arguments urged against any license bill are first, that a skilled engineer like a consultant for example called from state to state to advise and direct would require a license *for every state*, at great expense in money, time and trouble. Second, that a license would give the public a false sense of security by giving the state's stamp of approval to men as civil engineers who are as yet, or always will be, incompetent.

Can any argument be weaker than this when one compares the conditions as they exist to-day—with no license, no technical education, no requirements of any sort—and as they would be when the state, four years hence, shall exact at least a minimum of education, some experience, and compel a practitioner to think twice before he undertakes work for which he might be incompetent and thereby risks the loss of his license?

The objection sounds like the wild howl of the medical quack against being compelled to get a medical education before he tampers with a human life.

Of that the public has but one opinion. Argument No. 1 above was a serious one. It has been met in the amended McGrath bill by providing that a civil engineer licensed in any state where the license qualifications are as high as in this state shall be permitted to practice here without registry or expense. To anybody questioning his right to practice, he would of course have to exhibit proof of his being licensed and name the state from which he received it.

If that state was known by the records of our state regents to maintain standards as high as our own, no further or hostile notice could be taken of him unless he were observed to be guilty of unprofessional practice; in which case he would be called to the attention of our state authorities, fined and prevented from further practice in this state. Furthermore the matter would be brought to the notice of his own state for revocation of license.

Thus the argument No. 1 has no standing in the case of the McGrath bill. It falls flat. But the effect of a high-standard license would be to draw applicants in greatest numbers to the state issuing it, because that they would get with it both greater prestige and the

privilege to practice in every other state issuing as high or lower standard licenses.

The license from such a state would be as good as Federal license.

As the "N. Y. Times" has so well said editorially, "the principal opposition to this bill extending thus the system of licenses based on examinations by a competent state Board of Regents, is due to a misunderstanding of the amended bill's provisions or complete ignorance of what they are." It is really the latter. The density of that ignorance is past belief.

The intensity of the personal bias or selfish interest prejudice against the McGrath bill is shown on page 298 of Engineering News of March 9, 1911, when the Editor attacks the distinguished Regents of the University of the state of New York, who so ably uphold the standards of law, medicine, etc., by calling them "a set of respectable figureheads" and casting reproach upon "them as old" men of 61 to 81 years of age, "so long past the years of active progress" that " the education of the young should not be put in their charge."

The arguments and criticisms of Mr. Geo. B. Francis on page 361 of the News of March 23, 1911, are so laboured and fallacious and so many of them are met and covered in the latest draft of the McGrath bill that they are not worthy of serious consideration. But one should receive a passing notice. His claim that "the national engineering societies with age, etc., are a sufficient protection against incompetency," is amusing.

None of them except the Civil Engineers are anything but intermeddlers in this license bill notwithstanding several gentlemen have struggled to drag into it Electrical, Mining and Mechanical Engineers.

The greatest of the Civils, i. e., the American Society of Civil Engineers, exacts no earthly educational qualifications for membership; and interposes no obstacle that any man, with meager experience and three influential friends in the Society cannot easily overcome. And it is a mere private corporation ruled by a handful, mostly New Yorkers.

Even its membership is widely at odds on the subject. At its Chicago Convention last June it voted in favor of licensing engineers; and, in contradiction of the statements made by Electrical Engineer Sprague and others at the Albany hearings on the McGrath and Hoff bills, that same convention voted to oppose license legislation, not "unanimously" but by a vote of 201 against legislation to 200 for it, as is disclosed by their "Transactions."

When one realizes the conditions that now obtain in Civil Engineering, viz., that

Any barber, laborer, clerk, mechanic or clergyman can hang out a sign and practice without hindrance.

That an 18-year-old boy or ex-bartender can open a civil engineering office alongside a professor of engineering or a ten-year graduate of Cornell, Columbia or Rensselaer and ignorant though he be, compete for work and declare himself to be a civil engineer—and the public will not be able to discriminate. That another can build your imperfect bridges, your collapsing buildings, your unsanitary sewers, your polluted water supply works, your railroads and tunnels and squander public money on rotten highways. In dull times he can hire unemployed, educated engineers at starvation wages, as they often do now. Realizing the above and after reading "The Engineer's Preparation" by Mr. M. N. Baker, editor of the Engineering News on page 346 of his journal of March 23, one marvels at the nerve required to reverse himself and oppose any license law that seeks an educational qualification for the license. He states:

> To become possessed of these qualities requires far more than four years of the hardest possible study of purely engineering subjects. Broader subjects should be taken up, including a thorough grounding in purely cultural studies designed for the elevation and broadening of the mind and, for direct practical service likely to be in requisition any day, a fair working knowledge of at least the outlines of such subjects as statistics, accounting, civics, sociology, in order that the engineer may gain a full understanding of the many complicated relationships between man and government and man and man.

Do our colleges and civil engineering schools wish to continue such a state of affairs just because they fear the loss of some insignificant present prerogative when the Regents take charge of the civil engineers license examinations, as they already have of the law, medicine and others?

Even now, out of deference to their wishes, the amended bill omits all mention of preliminary educational requirements, regents counts, etc.

Are they to be allowed to obstruct our rights as graduates to be thus officially elevated to the dignity of a profession?

Especially when this bill gives equal privileges to every self-made or self-educated engineer now at work or to any man who chooses to begin study or practice at this minute? The bill limits only the unborn civil engineer.

The opposition to this bill exists nowhere except in the ranks of the one national society (whose rulers control it from New York City) and such of their members as hold important positions in other societies or colleges which they can influence.

The civil engineering apprentice who tries to become a civil engineer without studying or technically educating himself is almost unknown nowadays and should not be encouraged owing to the increasing intricacy and magnitude of modern public works, and the immense sums of money involved. The public has a right to its protection.

What the McGrath Bill does.

1. Requires civil engineers on public works only to be licensed after 1915.
2. Gives to all civil engineers now practicing a license without examination.
3. After 1915 requires a technical training, no matter how or where obtained, before an applicant can be examined for a license, and is not retroactive.
4. As amended, provides that a man licensed in any other state which requires equally high standards for licenses shall be permitted to practice here without N. Y. State License and without fee.
5. Provides for licensing of unlicensed, distinguished civil engineers from states not licensing.
6. It does not prevent any man from undertaking private engineering work here or elsewhere.
7. It is constitutional and within the police powers of the state.
8. In interferes with the charter rights of no university or technical school.
9. After four years it raises the standard of education among the practicing engineers of the future and promotes competence.

The advocates of this law urge every civil engineer to send to us a postal at once with his address and the words "in favor" or "against" a license on the lines above noted according to his views on the subject. We can then send him a copy of the amended final bill.

The Technical League,
W. G. Eliot, President.

By order of the Executive Committee, Gardiner L. Van Dusen, Secretary.

21 Park Row, New York City, May 3, 1911.

[We have given so much space during the past few months to the discussion of engineers' license laws that recent contributions opposing license laws which have been offered to us have been returned to their authors. We give space to the above letter, however, because we believe our readers will be interested to see just what the principal advocate of the licensing bills introduced in the New York legislature has to say in their favor; and it is a well-established custom of Engineering News to give a fair expression to both sides of questions of interest to the profession.

It is of particular interest to note that the writer of the above letter admits the organization of which he is President, (the Technical League), to be responsible for the presentation and advocacy of engineers' examination and license bills in New York, and that he also states that himself and the Secretary are the only two men alive "who know enough about the composition and identity of the members of that Engineering Society to even hazard a guess" (as to who and what these members are).

That is to say, the Technical League is not only a secret organization, but one in which a member is not allowed to know who the other members are. How can such an organization elect officers representative of the wishes of the members? How does anybody know that its President and Secretary really represent anybody but themselves? Is such an organization in any way qualified to represent the engineering profession? Does the profession or any considerable part thereof wish to have laws enacted limiting and restricting its work and establishing a tribunal with broad authority to govern the profession, such laws to be framed and furthered by the officers of such a secret society? We very gravely doubt it.

We shall not take space here further to present the reasons why, in our opinion, the proposed examination and licensing system would work injury instead of benefit to both the profession and the public, nor shall we even take space to reply to the various attempts of the President of the Technical League to criticise our position, except to say that the justification for any strictures we have passed upon that organization is found in the literature which it has circulated.

Engineers can judge for themselves from the above letter whether the President of the Technical League is sufficiently careful in his statements and temperate in his utterances to be qualified to represent the profession before the New York Legislature.

We take a single one of his statements as an example, regarding the attitude of the members of the American Society of Civil Engineers toward license legislation. The fact is that at the annual business meeting in New York, attended by over 500 members a motion was made that "it is the sense of this meeting that the licensing of engineers by States is undesirable." This motion was adopted by viva voce vote without a dissenting voice.—Ed.]

Photography for the Engineer.

Sir: The above title in the current issue of Engineering News gave promise of heading an article of considerable interest, and it was a disappointment to find that as far as any practical information to the engineer is concerned, the space is wasted. Had the author been an engineer, doubtless many of his claims would not have been made in such a positive manner. But for one in possession of knowledge superior to that of the average member of the engineering profession, it would seem as if a little more information as to the nature of the engineer's duties would have been desirable.

Your author makes no claims to instruct those experienced in the art of photography, but it seems hardly necessary to devote an entire page of Engineering News to give, for the novice, information found in the catalogs of camera dealers. Instructions for development are included with every package of films or plates purchased from a dealer, and the information given in regard to lenses is a paraphrase of the first part of a prominent lens maker's catalog.

I consider knowledge of photography of great interest and use to the practicing engineer, and for over 20 years, since my school days, I have been handling cameras of all types. Undoubtedly it is desirable for one who has time, to understand and practice all the operations of photography, including the work of developing and printing his own negatives, but with the present state of the art of manufacturing films and film cameras, such work is entirely unnecessary unless one desires to do it for his own pleasure.

Your author is very contemptuous of the use of the 3A Kodak or any exclusively film camera with an expensive lens. After an experience of a dozen years with two No. 3 Kodak cameras, it is to my mind the most universally adaptable of any variety for the purposes of the busy man who does not wish to lug around a bulky outfit, and who has no time to devote to fussing over the finishing of his own pictures. With the two cameras in question there have been taken several thousand views in the United States, Europe, and Central America. I once set up one of them on a shoring timber under 42d St. and Sixth Ave., and with the aid of a flash powder have taken an excellent view of sewer construction beneath the foundation of one of the elevated railroad columns. I have also taken progress views on horseback with one of these cameras, carrying it strapped to my saddle on inspection tours around work on the Isthmus of Panama, and have several remarkably clear pictures taken from moving trains with the same instrument.

These were all made with the ordinary lens equipment supplied with the camera. The great advantage in purchasing a higher priced anastigmat lens is for the possibility which it permits of making short exposures under unfavorable conditions of light, a matter which the author of your article neglects to state, and consequently it is far from being true that money is wasted in the purchase of such an outfit when intelligently used. I quite agree with your author that "the amount of money that is annually wasted in outfits that are nearly worthless is almost incalculable," as I doubt the ability of anyone to determine whether such an amount is small or great.

Your author, after reviewing and condemning various types of cameras including the film camera in all sizes up to 5 × 7 ins. and the reflecting camera—which he condemns on account of its bulk, although advocating an outfit of almost equal size, finally takes up and recommends for the general use of the engineer or contractor a combined hand and tripod camera using films and plates interchangeably of a size 4¼ × 6½ ins. and a lens of a type which he terms "controvertible," (meaning, I suppose, "convertible") anastigmat. I fail to follow entirely the reason for his choice of plate size, but I may note that in addition to my other equipment I have used for several years a camera that meets his specifications in many particulars. This is a standard "5 × 7" long focus folding box with a convertible anastigmat lens, volute shutter, and telephoto attachment, giving me with all lenses a range of focus of from 5 to 21 ins. and a varying degree of magnification above the combined lens of 7-in. focus, up to 7 times. There is a wide angle attachment of 5-in. focus for interiors and work at short distances. This camera is equipped for use with both roll-holder and plates, though I use the former almost exclusively.

When convenient it can be set on a tripod and the view composed and carefully focused before making the exposure, but I have had just as good success with the use of this camera where I have estimated my distance, setting the focus on the scale and catching my views

in the finder, and I think that not even a confirmed camera crank can determine any difference between the views made in either way. The main advantage of focusing on the ground glass is to be able to include just the right view desired in the picture as it is very easy after a little practice to estimate correct distances and get the focus on the scale, but where one has not time or opportunity to use a tripod the finder is almost always sufficient for properly centering the view, and the resulting print can be trimmed if too much has been included. This same lens can also be removed from its shutter and used in another tube in a Reflex camera for more rapid exposures on occasions when the ordinary finder is too small to enable one to compose the view properly. This is particularly the case when photographing objects in motion, when it is necessary to decide promptly the precise instant at which it is desired to make the view.

For field use in the tropics I had made a water proof pantasote carrying case, holding camera, roll-holder, and extra lens equipment, which gives a very satisfactory outfit for taking 5 × 7 views, although somewhat bulky to carry around except on special occasions. In spite of the advantages of this outfit for making the best class of pictures, I find frequently that my little 3¼ × 4¼ folding film camera has produced views, which when enlarged are practically as good as those made by the other. In a series of lantern slides, which I possess, it is difficult to detect any improvement in the quality of the views made by the 5 × 7 camera over those made by the 3¼ × 4¼.

What your author says in regard to composition is merely a statement of the fact that it is necessary so to select your view as to bring into prominence the parts desired. Now no one can secure such results by merely pointing a camera and snapping the exposures in the desired direction, but good views may be taken by one who has never had the time or the inclination to do his own developing. A professional photographer is almost always available to whom exposed films may be sent and the results of development will be practically as good as those obtained when laborious personal attention is given to the developing of each separate negative. As a compromise between the two methods the possessor of a camera may very easily finish his negatives by the use of a tank developing machine. Such an apparatus I have found very convenient for tropical use when I did not care to risk retaining many rolls of film undeveloped for long periods, and after spoiling a roll of valuable exposures in an attempt to develop individually in a tray under somewhat the same conditions as advocated by your author for the use of an engineer in the field, I depended entirely upon two developing tanks for finishing several hundred negatives exposed at Panama, with universally favorable results as far as the work of development itself was concerned. This method is particularly advantageous where it is difficult to obtain the use of a dark room.

It is rather amusing to read the didactic remarks of the author in regard to the desirability of an engineer or contractor setting up his camera on a tripod and carefully and laboriously developing his pictures afterward in a dark room. It is a little difficult to imagine the average contractor on the occasion of a derrick back-stay snapping, or a loaded team backing over a dump, going to his office to return with camera and tripod which he carefully sets up and focuses before assisting in the repair of damages, or the engineer engaged on preliminary survey work after a hard day's work in the field, with notes to plot and estimates to work up, sitting down in his dark room and carefully developing two or three dozen plates taken with his portable outfit for which he has paid less than a dollar. I have been making progress views of engineering work for over 16 years and while I personally enjoy carrying on all the operations of photography for my own amusement when I have time to do it, I have never been able to detect any improvements in the results over those obtained by forwarding rolls of film as soon as exposed to a professional photographer.

Your author undertakes to instruct the engineer as to the method of photographing steam shovel work in a bank, emphasizing the importance of bringing out the salient features of the shovel, but he does not recognize the fact that very frequently it is the bank that is desired to be shown. Most engineers understand the appearance of the steam shovel and the common purpose of a photograph is to show the conditions of the work at any given time, not the minute details of the tools with which the men may be working. In Figs. 1 and 2, where it was attempted to show the advantages of a convertible lens, the same result in reducing the angle embraced could have been made in probably the same time, if instead of changing the lens combination the photographer had moved his camera. This is not to condemn the convertible lens, of which I make considerable use, but too much emphasis should not be placed on its importance, and for the man who does not care to spend a high price for such an outfit as I advocate, which has in my case aggregated over $150, there is no camera that will give more all round general satisfaction than a No. 3 Kodak or any one of several other equivalent types made by competing firms. As samples of work done by such cameras, I can submit scores of specimens, any of which shows infinitely more detail than the views illustrating this article.

Very truly,
Henry Welles Durham.

Sandwich, Mass., April 14, 1911.

A Proposal to Extend Manhattan Island Four Miles Down New York Bay.

Sir: For many years there has been more or less complaint that New York is not able to afford sufficient accommodation to shipping and many more or less inadequate schemes have been suggested. The New York Central R. R. West Side tracks also have been an unending source of agitation.

We have frequently heard that New York would be supplanted by Montauk Point as a shipping center, or even by Boston or Philadelphia. This, with New York's magnificent natural advantages, seemed so radically wrong that the writer spent considerable time studying the matter, even when "burning the midnight oil" with the aid of the jerks and grind of the Manhattan elevated trains to prevent sleep. He was finally led to write to Mayor Gaynor on April 4, 1911, the following letter accompanied by a map. If the plan suggested in this letter should be adopted, it would undoubtedly solve the problem of New York's unrivaled supremacy as a port for many generations, if not for all time:

Hon. Wm. J. Gaynor, Mayor of New York.

Sir: Knowing that you and Mr. Tomkins are deeply interested in the future welfare of New York Harbor facilities, I take the liberty of submitting a scheme which it seems would accomplish all that you are after and more, and far more than pay for itself, as it would at once add 1,400 acres of the most valuable waterfront land in the world to New York City, to say nothing of the great increase in the value of Staten Island.

As an engineer, I know that there are no obstacles to prevent absolutely safe and economical construction.

My proposition is simply to build substantial sea walls a little over half a mile apart from the Battery towards Staten Island for about four miles.

Between these sea walls place two four-track subways and then fill in the remaining space by pumping sand out of the channels.

From these concrete sea walls, docks could be built out as required.

From the end of this new made land to Staten Island construct an eight-track tunnel, and then encircle Manhattan and Staten islands with four-track tunnels to carry any full-sized freight car.

In order to be brief, I have not gone into detail, but it would take a very vivid imagination a long time to think of all the ways in which this would develop Manhattan and Staten islands.

Trusting that you will persuade the War Department to sanction this means of making New York City the greatest port in the world, I am, Sir,

Yours respectfully,
T. KENNARD THOMSON.

For many years the writer has maintained that New York City is no place for a terminal, as it is too big and too contracted. What it needs is distribution in the fullest sense of the word, not concentration of either men or material. With this end in view he published in the "Brooklyn Eagle" some 13 years ago a plan which, if adopted, would have solved the Brooklyn Bridge problem, as most people acknowledged at the time although the question of expense frightened them.

The plan was simply to extend the Brooklyn Bridge to the North River and then northerly and easterly to connect with the Williamsburg Bridge. If this had been carried out, the people would have been distributed at a dozen different points instead of all concentrated at one point as at present.

This plan was submitted to Mr. Alexander E. Orr, of the Rapid Transit Commission. Instead of answering the letter Mr. Orr appointed a Commission of other engineers who proposed the loop between the two bridges now under construction which will never afford the relief that the North River loop would have done, as the bulk of the people will still be concentrated at City Hall Park.

This is simply cited to show one of the reasons why distribution of men and material is absolutely necessary for any well considered plan for New York.

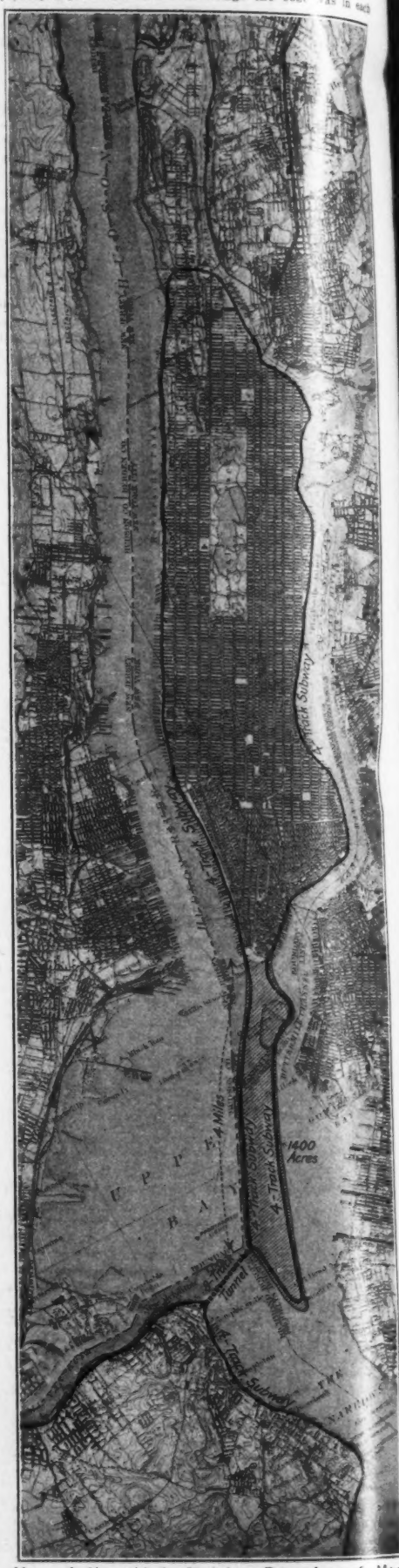
Obviously anything in the line of a freight terminal or series of freight terminals on the west side should not be considered for one minute; nor any system involving transfer of freight cars from river floats to an elevated structure over steep grades, short curves, &c.

All these considerations caused the writer to evolve the plan submitted to the Mayor on April 4, to endeavor to solve the freight problem, dock problem, and general growth of New York in one operation.

The plan mentioned simply consists of building two parallel sea walls about one-half mile apart from the Battery down the bay towards Staten Island—about four miles long; and building a new city of 1,400, or so, acres area between these two sea walls. This area would be equivalent to that contained between 10 blocks (north and south) of Manhattan for the width, and from the Battery to 42nd St. for length.

From the 8 miles of new sea walls, piers could be built as desired; also dry docks, warehouses, mechanical plants for rapid loading and unloading, etc. The present depth of water where the new city should be, is from 20 ft. near the Battery to about 60 ft. near the Staten Island end; while the water in the channel to be left, between the end of this neck and Staten Island is now in some places 70 ft. deep.

Wherever rock can be found within 100 of the surfact, it would probably be advisable to sin caissons all around and pump out the enclosed ar for laying foundations. It might be stated here th the foundation for one skyscraper in lower Ne York cost $1,500,000; for two other buildings the cost was in each



Map of New York Showing Extension of Manhattan Island from the Battery Southward, Proposed by T. Kennard Thomson.

case about three-quarters of a million, with many others at several hundred thousand dollars. This shows how valuable the new land would be when made ready for skyscrapers with comparatively no work for foundations.

Where the rock cannot be reached at 100 ft. below the water, piles could be driven and cut off many feet down and then caisson sea walls could be sunk on top of the piles—not a new operation, as far as piles and caissons are concerned—and the intervening space filled with sand pumped out of the channels, which would thus be deepened and widened wherever necessary, especially the Buttermilk Channel.

Governor's Island would simply be a small spot in this new city and could be retained by the Government or turned over to the city as desired. If necessary, the city could manufacture a new and finer Governor's Island elsewhere.

The eight or nine miles of the finest docks in the world which could be built on this extension of Manhattan Island would undoubtedly suffice New York for many years to come. When more accommodation was needed in addition to Jamaica Bay, it would be possible to construct breakwaters along the whole length of Staten Island, or possibly to even build a new strip of land, say half a mile or a mile wide and 15 miles long, parallel to Staten Island from the Narrows, south. In short it would take a Jules Verne to imagine all of the possible developments of the scheme.

While the first 1,400 acres are being added to Manhattan from the Battery towards Staten Island, a four to six-track freight railroad should be built around the entire water front of Manhattan and Staten Island, being joined, of course, by a tunnel under the channel at Staten Island; a loop of over 60 miles.

On the plan sent to the Mayor, subways were shown; but personally I would prefer an elevated structure, except for the approaches to the tunnel under the Staten Island channel.

An elevated structure is very much cheaper to build, healthier, and in addition would be about on the level of the big steamer docks, which would make handling of material much cheaper. An elevated structure is in no danger of being flooded.

Of course, as Staten Island was connected by this freight belt line, which would connect with the New York Central and New Haven on the north, the Baltimore & Ohio R. R. and the Pennsylvania R. R. on the south, and all the other roads on the west side of Staten Island; then two or more four or 6-track passenger lines would be required from the south end of Staten Island to Yonkers, or perhaps much farther; and these in addition to all the proposed subways for Manhattan.

The passenger transportation lines on the new neck of land and in Staten Island, should be built not on the streets but through the center of the future blocks of buildings (as proposed for Manhattan many years ago, I believe, by Mr. Max Lewinson).

Staten Island is at present assessed at $50,000,000 and it seems to be universally believed that when my scheme is carried out that this value will be increased ten times, to $500,000,000. What the value of the new neck of land would be is, of course, problematical; but if it was worth only 1/42 of what No. 1 Wall St. sold for, it would be worth one billion dollars, so these two items alone would be worth at least 1½ billions of dollars, which is far more than the whole scheme would cost to construct to say nothing of the value of the docks and of having freight sidings all around the two islands.

So prominent bankers tell me that there would be no difficulty in financing such a proposition and there are plenty of able engineers and contractors who are confident that they could easily carry out any part of the work involved.

There are, to be sure, a great many very interesting engineering questions to be solved, but no unsolvable ones, such as the shape of the walls, the expansion joints in watertight sea walls, etc.

One effect that this new city would have on the Narrows would be that, roughly, about 223,000,000 cu. ft. less water would pass through the Narrows with every tide (four times a day), being the volume of water between high and low tides that would then be filled with land, or $2{,}650 \times 5{,}280 \times 4 \times 4$ ft. $= 223{,}872{,}000$ cu. ft. The neck would also act as a breakwater for the Brooklyn shore, and as the volume of water at any point in the new channels would be greater than that now required by the East and North Rivers, therefore the only effect my scheme would have on the water would be to control it and slightly reduce the velocity at the Narrows without changing the level.

When building skyscrapers, one would naturally want to occupy the whole block, not fragments of a block. It can easily be realized by all how difficult it is to find any such obtainable blocks on Manhattan. This scheme would allow rationally laid-out skyscrapers and the construction of a City Beautiful, and provide a fine site for a new Court-House without stealing from poor old City Hall Park. In fact, a finer park could be left around the new Court-House.

One result would be the relief of congestion on the rivers, which is bad enough now and will rapidly become worse if this plan is not carried out promptly. Ocean liners will be able to slide easily into ample dock as soon as they pass the Narrows, saving more than an hour's tedious travel up the Bay and North River, and the worry of making small craft keep dodging.

Hudson River boats will be able to land near the Battery, on the North River side, and the Sound boats which now have to double around the Battery in order to land their passengers near some transit line, will then find good dockage near Governor's Island, while the car float will disappear, as the freight cars from any part of America, Long Island included, will be quickly moved by rail to the exact point required. This alone would release a great many docks and greatly simplify the river traffic.

These remarks refer to the condition of the rivers in fine weather—we all know what the conditions are in a fog.

If the people ever realize how this would benefit New York, the population of which is already increasing at a rate of over 200,000 a year, they would not allow anything whatever to stand in the way. All that is necessary to so convince them would be to make accurate surveys, borings, plans and careful estimates of what the work would actually cost and compare this with careful estimates of the resulting benefits.

Yours respectfully,

T. Kennard Thomson.

50 Church St., New York City, May 1, 1911.

[History repeats itself. Twenty-three years ago when New York was scheming to secure the Columbian Exposition, it was proposed to make a site for the Exposition by enlarging Governor's Island and increasing its original area of about 68 acres to about 232 acres. In Engineering News of Sept. 28, 1889, a full description of the scheme was published and it is noteworthy that it was vouched for by such eminent engineers as Col. Julius W. Adams, Wm. E. Worthen, Wm. J. McAlpine and Arthur M. Wellington.

The Columbian exposition was secured by Chicago and nearly a score of years later the Federal Government undertook and carried out the work of extending Governor's Island by filling in the shoal water lying to the southward.

Mr. Thomson's proposal to extend Manhattan Island with the aid of present day appliances for dredging and transporting material is little more bold than was the proposal to extend Governor's Island 23 years ago.

On the other hand, it is by no means certain, that such an encroachment on the water area of the harbor would be on the whole advantageous to New York City. Before any such extension of Manhattan Island is undertaken, the unused water frontage included in the Greater City should be developed. The shores of Long Island and the land abutting on the East River and the Harlem River are as much a part of the port of New York as is the Hudson River frontage on Manhattan Island, where congestion of traffic is just now attracting attention.—Ed.]

Social Philosophy and the Taylor System—Will the Ultimate Result of the Taylor System Be Beneficial?

Sir: Various writers are now engaged in showing that, by the Taylor system of shop management, production may be increased or the cost of manufacture lessened. Being convinced that they will prove their contention, and that the Taylor system or some similar system of efficiency engineering will be universally adopted, I propose to consider the final result.

In Mr. Taylor's first great success in increasing the amount of pig-iron that a man could load on the cars in a day, the wages of the men were about doubled and the production increased four-fold. These men, doing the most unskilled labor, and belonging to no union, were said to be perfectly satisfied with their increase of pay, and Mr. Taylor assures us that a greater increase of pay would have been harmful to them, as it is bad for men to get rich too fast.

Mr. Taylor is of course subjected to criticism from two sides, from the workingmen and their friends who think that the increase in pay ought to be in proportion to the increase in production, and from employers who grudge the increase in wages which seems proper to Mr. Taylor.

In cases where material may be spoiled by poor work, the Taylor system may cause a saving of material, but when the material, like pig iron, is indestructible, there is no opportunity for this gain. Therefore, for the sake of simplicity, we may leave the cost of material out of consideration, and regard the expense of production, under the Taylor system, as made up of: cost of labor, L_2; cost of management, M_2; and capitalists' profits, P_2. Similarly under some other system the entire expense would be $L_1 + M_1 + P_1$. Then it is evident that in order that the employer may desire to introduce the new system, the increase in wages must be such that $P_2 > P_1$, or $L_2 + M_2 < L_1 + M_1$ for a given article or given amount of manufactured material. But since M_2 must be greater than M_1 [?] it follows that the increase in wages paid to workmen cannot be as great as the increase in production. Those who argue that a laborer should be paid the full value of the product overlook the fact that the owners of the business are entitled to a reasonable profit. In estimating the cost of getting a piece of work done, an engineer would never omit the item of profit to the contractor, and the owner of a shop is often very much like a contractor, both as regards the money he invests, and the amount of personal attention he gives to the management.

Workmen do not like the new system because they regard it as some scheme for making them work harder, and because they dislike the extra amount of oversight to which they are subjected. Therefore to induce them to accept the Taylor system it is necessary that $L_2 > L_1$ where L_2 is the wages per day under the new system, and L_1 the wages under the old. It does not necessarily follow, however, that the amount of increase required to persuade men to try the new system, is a just and fair share of the benefits of the system. If all shops were run under the new system, and men were unable to get work under any other, they would have to work even if $L_2 = L_1$. Leaving out the transition period when $L_2 > L_1$, it is evident that the Taylor system offers no guarantee to the working man that an increase of wages will be maintained after all shops have adopted the system.

Under this system, then, we shall come back to present conditions, namely, that apart from public opinion, there is no limit to the greed of an evil-disposed capitalist except the starvation of his workmen, and no limit to the greed of an evil disposed and sufficiently powerful labor union except the bankruptcy of employers. Just as there used to be slaveholders who treated their slaves kindly, so there have been benevolent employers. Peter Cooper is said to have run his blast furnaces at a loss for several years in order to avoid throwing his men out of employment. Neither do I mean to say that all labor unions are grasping, but when they are employers are at a disadvantage in making agreements with them, since an employer may be sued by any individual member of a labor union if he breaks a contract, but the labor union being an unincorporated body, the employer has no redress if a labor union does not stand by its agreements.

It is claimed that the Taylor system is like the introduction of labor-saving machinery; that productivity means prosperity. If a man were paid in proportion to the value of his services, that is if the value of a manufactured article were divided among the producers in the ratio in which each contributed towards its manufacture, then productivity would mean prosperity for all. But is this now the case? Is the worker in a sweatshop to be envied by the savage? A savage, untouched by civilization, without ideals for anything higher than the life he has led, might, it seems to me, be very happy. But the sweatshop worker must inevitably have before him the thought of those for whom he is working, who are much better off than he. Those who aspire for higher things, but who can see no hope of improving their condition, are surely deserving of pity.

It is impossible to deny that both the introduction of labor-saving machinery and labor-saving methods has been a blessing to those who play the part of consumers rather than of producers, but incidentally both machinery and methods require capital for their introduction, and they tend to drive the small employer out of business and replace him by the large corporation. And the result of this process has been to place the workman at the mercy of the capitalist, except where labor unions are powerful. The Taylor system does not alter but only intensifies this.

While we may admit that it is not the aim of the Taylor system to make men work beyond their strength, we may yet doubt whether the system may not be abused, whether even the best intentioned employers may not be led to work their men at a pace that kills. The effect of overwork does not appear in a day, a week, nor a year. Time alone can prove whether a man can continue to thrive from youth to old age with incessant labor or only a scientifically prescribed number of restful moments during working hours. Americans are already noted for working harder than any other nation, and students of immigration tell of the common complaint that foreigners cannot stand the strain of work in America. It is fairly evident and well known that cases of nervous breakdown are increasing in number. Yet Mr. Taylor's cry is "no more soldiering." I protest, we work altogether too hard now. We spend too much time on making money, and not enough on getting the most good out of what we have. Introducing the Taylor system is like turning a street-car controller around to the next point of contact. The question is, will the fuse burn out?

If we were suffering from underproduction the Taylor system would be an immediate relief; if from overproduction, it can only make matters worse. If we had underproduction we should export nothing, whereas in fact we sell goods cheaper abroad than at home, all manufacturers are crying for foreign markets, and the United States are tending to join the other nations in rushing nearly to the verge of war in their efforts to

satisfy the manufacturers. In spite of these frantic efforts and the curtailment of production both by the action of labor unions and associations of manufacturers, the surplus accumulates till all warehouses are full, goods are a drug on the market, hard times are said to have come, and they are only relieved when, after long idleness of mills and heavy losses both to employers and workmen, consumption has caught up with production.

The remedy is evidently to increase the consumptive power of the nation. The Taylor system does this, to be sure, as wages are increased, but since the advance in production is greater than the increase in wages, the result must be an intensification of the evil effects of overproduction. Many schemes of profit sharing, co-operation and the like are good when employed, but they presuppose a philanthropic spirit on the part of the employer which is not always present. Unselfishness has been preached for thousands of years with discouragingly slight effect; and it seems as if in the end we should have to make up our minds that human nature is naturally selfish, that it cannot be changed, and that the thing to do is to devise a system under which selfishness will be the motive power to cause every man to act for the greatest good of the community. If half the effort had been expended in trying to discover such a system, that has been spent in trying to change human nautre, no doubt it would have been discovered long ago.

It is not my purpose to advocate any proposed system. Bellamy, Henry George, MacKaye and others all have their systems, and perhaps none of them is exactly what is wanted. But they seem to me at least to be striving after a good ideal, whereas the Taylor system has for its immediate result to make matters worse. Yet, taking a very long look ahead, we can see that when the time shall come when every man shall be a worker, and every worker shall receive the full value of his labor, anything to increase the value of that labor, that is to increase the purchasing power of a man's labor, will be a blessing to humanity. Under such circumstances the Taylor system, or any system of efficiency engineering to increase production, must certainly have the effect of shortening hours or increasing wages for everybody. But till we have a system of remuneration in proportion to the value of labor performed, there is nothing in the Taylor system to prevent the rich from getting richer, or to enable the poor to obtain more than a bare subsistence.

Winslow H. Herschel.

236 Newbury St., Boston, Mass., April 23, 1911.

[The aim of "efficiency engineering" or the Taylor system, as our correspondent terms it, is to accomplish the same end as the invention of labor-saving machinery, to make a given outlay in labor time produce a greater result. Admittedly there are competitive forces at work tending to reduce the rates of wages and neither the introduction of labor-saving machinery or the adoption of efficient management so that the workers produce a maximum amount, prevents the operation of these forces. To illustrate, suppose a hundred firms are manufacturing paper boxes. One firm introduces a new machine which doubles the production and for a time it can make large profits and if it chooses to be generous can pay extra high wages as well. But other firms also will put in similar machines and when their use becomes general the competition between different concerns will reduce the selling price of the product and the profits and will compel the reduction of the wage scale as well, no matter how generous the individual employer may be.

Exactly the same thing will happen if, instead of a labor-saving machine, a more efficient system of using labor—a Taylor system—is put in operation, first by a progressive concern and then by all the live concerns in the business. Competition will tend to reduce the selling price of the product, the profits and the wages paid or which can be paid to labor.

The Taylor system, therefore, will not prove a panacea for such evils in connection with the inequitable distribution of the products of industry as our correspondent sets forth. It is not, in fact, advocated as such a panacea by its most judicious friends.

On the other hand, it is not by any means as easy or simple a matter to establish real and lasting efficiency in a concern as it is to buy certain new machines. A pretty large percentage of concerns which attempt to instal efficiency engineering will succeed in tying up their operations with red tape and will increase total costs instead of cutting them down.

Mr. Taylor has performed an inestimable public service in developing methods by which an able and progressive management can secure a large reduction in operating costs; but the application of these methods calls for a grade of ability that is not always procurable and the "universal adoption of the Taylor system," to which our correspondent looks forward, is so far in the future that the concerns which do successfully instal it will have plenty of chance to pay good dividends and increase wages as well before competition becomes severe.

The criticism of the Taylor system on the ground that it forces men beyond endurance and causes premature breakdown, is an important one and applies to much of the work carried on under the modern industrial system. What scientific management ought to do and what it does do when most intelligently applied is to remove the difficulties in the way of the worker and enable him to reach an increased output without overstrain, mental or physical.

As for overproduction and "under consumption," these are apart from the main subject of our correspondent's letter. We merely suggest that in the last analysis there is no such thing as overproduction, and cannot be, so long as human wants and desires are unlimited. The trouble is that our machinery of production and exchange and distribution of the products of industry does not work properly.—Ed.]

Radius-bar Length and Swing of Locomotive Trucks.

Sir: A formula that has been used for a good many years to determine the swing of a locomotive truck from its central position due to curvature of the track has sometimes been wrongly given, and as it is probable that few have ever taken the time to verify it, or to determine its limitations, a derivation of the formula may not be out of place.

The formula is derived from the expression which gives the correct length of radius bar for a "pony" or two-wheeled truck so that the truck axle will stand radial to the curve. Then, strictly speaking, the formula is applicable only to pony trucks, and only when the radius bar is of correct theoretical length.

In the following discussion the radius bar will be first treated.

LENGTH OF RADIUS BAR.—Let

l = distance from the center of back drivers to center-pin of truck.
a = length of rigid wheel-base.
b = distance from center of front drivers to center-pin of truck; $a + b = l$.
r = length of radius bar.
R = radius of curve of track.

The line $M\ N$ in the diagram herewith is the center line of the engine. The graphical construction commonly used is shown in the elevation, in the upper part of the figure. Referring to the lower part, or plan, we are to locate the center of truck swing, O, such that OB will be tangent to the curve. The lengths a and b are given. By geometry the length OB of a tangent to a circle from any point O, and the segments x and $(x + a)$ of any secant OM from O, are so related that

$$OB^2 = r^2 = x\,(x + a)$$

Substituting in this equation the values

$$x = b - r,$$
$$\text{and } a = l - b,$$

gives

$$r^2 = (b - r)(l - r) = b\,l - r\,(b + l) + r^2$$

or $$r = \frac{l\,b}{l + b}$$

which is the desired formula.*

The graphical method is easily proven, as follows:

The distance OA being called c, and the distance from A to the center line of the engine being called d, we have

$$c^2 - r^2 = R^2 = d^2 + \left(\frac{a}{2}\right)^2$$

from which $$c^2 - d^2 = r^2 + \left(\frac{a}{2}\right)^2$$

Also, $$c^2 - d^2 = \left(\frac{a}{2} + x\right)^2$$

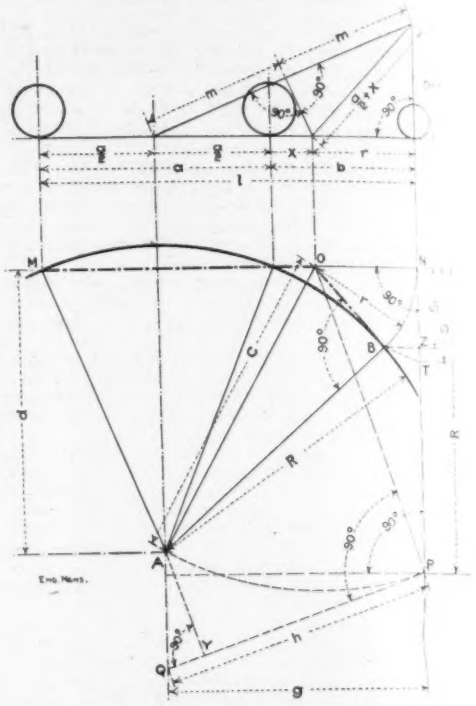
Hence $$\left(\frac{a}{2}\right)^2 + r^2 = \left(\frac{a}{2} + x\right)^2$$

The diagram in the upper part of the illustration shows how this is applied. Laying off half the rigid wheel-base or ½ a upward from the truck wheel, and drawing the diagonal from the upper end of this line to the center of the rigid wheel-base, a perpendicular erected to this diagonal at its middle point cuts the base-line at distance x from the front driver. For, the small right triangle gives the equation

$$\left(\frac{a}{2}\right)^2 + r^2 = \left(\frac{a}{2} + x\right)^2,$$

which is the formula derived above.

SWING OF TRUCK.—For the purpose of examining the truck swing, imagine the triangle OAB to be rotated around the radius-bar hinge O until the radius-bar coincides with the center line of the engine. The triangle then is in the position OPN. Now draw PQ perpendicular to OP as shown, and draw AY perpendicular to PQ. If BZ be drawn from B perpendicular to NP, it is obvious that the figure $OAYPO$ is similar to $OBZN$. If a small triangle BZT is made similar to AYQ, the figure $OAQPO$ is similar to $OBTNO$, the side NT of the latter figure corresponding to PQ of the larger one.



Determination of Radius-Bar Length and Swing of Locomotive Truck.

Although $NZ = S_1$ is the actual swing of the truck, the solution is much simplified by assuming the swing to be $TN = S$, the error being equal to the side ZT of the small triangle and on the side of safety. For given engine dimensions, the size of this triangle and the angle ZBT becomes smaller as the radius of the track curve is increased, and for curves found in practice the error is negligible.

From the similar figures mentioned,

$$\frac{h}{c} = \frac{S}{r}$$

Also, by similar triangles,

$$\frac{h}{g} = \frac{c}{R}$$

Eliminating h from these two equations,

$$\frac{cS}{r} = \frac{cg}{R}$$

from which,

$$S = \frac{gr}{R}$$

Substituting the value of the radius-bar length and the value

$$g = \frac{a}{2} + b = \frac{l + b}{2}$$

gives

$$S = \frac{lb}{2R}$$

Kent's "Mechanical Engineers' Pocket-Book," 8th ed., p. 1093, gives a wrong formula containing a in the numerator where b should appear.

The ordinary four-wheeled truck swings directly toward the curve center, taking a position on the rails nearer to the drivers than would be the case if a radius bar were used. The swing is therefore less and while the formula does not apply theoretically it is on the safe side.

The four-wheeled truck formula and the exact formula for the pony truck are exceedingly clumsy. The formula given above is probably accurate enough for all ordinary problems involving a knowledge of truck swing.

William E. Ninde.

Syracuse University, Syracuse, N. Y., March 25, 1911.

*This formula, expressed as $x = \frac{b\,(a + b)}{a + 2\,b}$, is given in Meyer's "Modern Locomotive Construction" (1892), but without proof.—Ed.

Members of the American Institute of Mining Engineers on the Panama Canal Work.

The resolutions adopted by the members of the American Institute of Mining Engineers who visited the Panama Canal work last November, expressing their approval of the plan of canal and of the methods in force on its construction, were printed in our issue of Nov. 17, 1910, p. 549. In the January "Bulletin" of the Institute, 84 pages are devoted to printing the views of individual members of the party. We print below brief extracts from some of the most important of these opinions, choosing as particularly noteworthy the opinions with reference to the type of canal and with reference to the slides in the Culebra Cut.

W. S. AYRES, Hazleton, Pa.—Having myself been actively connected with the work of stripping the surface material from portions of the anthracite coal beds of eastern Pennsylvania, where a width of 600 to 800 ft., by a depth of 300 ft. and a length of several miles, amounting to millions of yards, has been removed, I readily recognize in the vast scheme of steam-shovel and dredge excavation, and in the transportation, many well-known and thoroughly tried methods; but here on the great canal they have been greatly improved, and wonderfully increased in scope of operation.

Next to the work of sanitation, without which marvellous achievement all other work would have been impossible, the transportation scheme impresses me as the key to the situation. I have never before seen such perfection of detail in a long-haul system, auxiliary to construction.

I will make only one other observation, namely, as to the slope angles of the banks of the Culebra cut and the "slides" that are occurring there. The "creep" of the "slides" will, after the final depth in the cut is reached, grow less and less, and in time will cease entirely. The 300-ft. width of the bottom of the canal in the cut makes it very improbable that navigation will ever be even delayed by these slow-moving slides, the maintenance dredges being amply able to remove the material fast enough to keep the channel clear.

ALEXANDER L. BRODHEAD, Catasauqua, Pa.—Among the many lasting impressions which I have received, the strongest is that of the marvellous efficiency of the organization of the work on the Isthmus, and particularly the ability of its chief. Here is a man who, with the United States Treasury at his back, giving him practically unlimited means, is not, so far as could be observed, spending a penny unnecessarily. It is extremely doubtful if any private contractor watches the details of his expenses more closely than the Chairman of the Isthmian Canal Commission. Some people might say that it is not necessary to spend such large sums on the pleasure and comfort of employees; but it seems to me that the efficiency of the men is a sufficient answer to that criticism. Although wages are necessarily high, the unit costs show that every man is earning his pay.

D. W. BRUNTON, Denver, Colo. (President of the Institute).—To an engineer visiting the Isthmus, the most striking feature is the almost perfect adaptation of the canal plan to meet existing conditions. By the simple expedient of building a dam across the valley of the Chagres at Gatun, that unruly river is forced to become the servant instead of the master, and a lake is created, over which vessels can steam at full speed for one-half of the distance separating the Atlantic from the Pacific. In addition to this, this immense body of water, 164 sq. miles in extent, automatically takes care of the terrific floods which occur on the Chagres and its tributaries; and, as good fortune would still further have it, the lake extends 7 miles up the valley of the Chagres River beyond Bas Obispo, the point where the canal leaves the lake, thus forming an immense settling basin, which will effectually take care of the debris brought down by the river during floods, so that the portion of the lake traversed by steamers will not be filling up with sediment. Incidentally, the head of water created by the dam will furnish power for a hydro-electric plant which will not only operate all the machinery employed on the canal, but light it as well.

One good look at the Chagres River in flood and another at the Culebra cut, with the rapidly disintegrating rock on its sloping sides, would effectually cure any engineer of the desire to undertake the construction of a sea-level canal, which, even if it could be built at any reasonable cost — which is extremely doubtful — would afford a much slower passage from ocean to ocean than the 85-ft. level-lock canal. The time lost in passing through the locks would be more than regained by the high rate of speed at which vessels could traverse Gatun Lake.

So much has been written and said about the Gatun dam that every one was especially anxious to see that great undertaking; but, apart from its immense size, it does not differ materially from many of the irrigation dams in the West, where the principles involved in its construction have been thoroughly tested. It is, of course, less impressive now than it will be when completed; but even then, when its gentle slopes of 1 ft. in 10 will be covered with water on one side and tropical vegetation on the other, it will be nothing more than an artificial ridge, 1,900 ft. wide at its base, 1.8 miles long, and 115 ft. high, extending across the Chagres valley.

W. J. DAVIDSON, Port Richmond, N. Y.—The opinion I had previously formed was that the work was not being conducted in a practical and businesslike way; that it was oversystematized; and, last but not least, that the canal undertaking was about one-half the size I found it to be.

I was very agreeably surprised to find that my ideas were entirely wrong. When I saw the magnitude of the undertaking I was spellbound, and it became very apparent to me how it was possible for the French, or any other nation, to "go broke" on such a job, in view of difficulties with which the pioneers of this task had to contend, and the inadequate means and knowledge they had at their command to fight tropical diseases, and effect by drainage, etc., a thorough sanitation.

The work is being pushed with the greatest speed I ever saw in any such work. These seems to be absolute harmony among the departments, each striving to its utmost capacity to keep ahead of the next. Every person employed seems to have but one object in view, namely, the finishing of the task undertaken within the time set for its completion.

My feeling in this matter can be summed up by saying that, in my judgment, the government is getting more value for its dollar on the Isthmus of Panama to-day than any private contractor or contractors could possibly give it, and general conditions everywhere about the Canal Zone are in a clean and healthy state.

DR. HENRY STURGIS DRINKER, South Bethlehem, Pa.—To Col. W. C. Gorgas, M.D., is chiefly due the credit of the organization and effective operation of our splendid Sanitary Department on the Isthmus, which has resulted in transforming it from a plague spot into one of the healthiest places in the tropical belt. His work, and that of his organization, made possible the engineering work which now, under Colonel Goethals, challenges the enthusiastic admiration of the engineering world.

When we realize the frightful insanitary conditions under which the French worked, the wonder is not that with their great resources they failed, but that they had the energy and persistence to accomplish so much. They did all that the medical science and knowledge of their day taught them to do. They built, at great cost, good, large, airy hospitals, with open windows, unscreened, where their yellow-fever and malarial patients received careful attention, but which were simply ideal places for the propagation of yellow fever. The *Stegomyia* mosquito would flit in, sting a yellow-fever patient, and in due course communicate the disease to some uninfected patient cared for in the same hospital, and suffering from some other complaint—and the *Anopheles*, or malarial mosquito, was afforded the same facility for work.

WILLWARD DUFFIELD, Harlan, Ky.—I was strongly impressed with the following facts:

1. The vast superiority of the present plan of a lock canal over the sea-level plan, which, before visiting the Isthmus, I had always believed to be more desirable.

2. The wonderful efficiency with which the work along the entire zone, including the lock and dam construction and the Culebra cut, is being carried on. The movement of earth from the great Culebra cut alone, and the vast number of trains handled over the tracks without confusion, delay, or apparent car shortage, deeply impress a railroad engineer with the efficiency which must be behind the management of this branch of the work; and the rapidity with which stupendous quantities of concrete are being put in place, day after day, without delay for material, forms, or anything connected with the work, and in spite of the difficulties attendant upon the heavy rainfall, shows equally efficient management and direction for the constructive part of the work.

3. The marvellous change in the sanitary condition of the Canal Zone, particularly in the cities of Colon and Panama, which has been effected during a few years, and the practical elimination of the mosquito, and with it the dread fever to which the zone was formerly subject. It was an astounding fact to me that during my entire visit I did not see a solitary mosquito, though I was all over both the Gatun dam and locks and those of Pedro Miguel, and the visible conditions seemed to be especially adapted for producing the mosquito.

4. The solidity and permanent character of the great Gatun dam, upon which I spent two days, going over nearly every foot of ground. One has seen frequently in the papers during the past two years intimations that the dam would not hold; that it would slide under the pressure of the 85 ft. of water; but after a careful inspection on the ground itself, one comes away with the belief that the dam, when completed, will be as permanent as any of the natural ranges of the Isthmus.

An American engineer returns from a visit to the Canal Zone proud of the fact that he is the citizen of a nation whose government is successfully, ably and rapidly completing the greatest piece of engineering work in the world's history.

HOWARD N. EAVENSON, Gary, W. Va.—In my opinion, the present plans for a lock canal cover the only feasible scheme. The machinery used seems to be of the best kinds, and to be adequate for its purpose. The personnel of the organization and the *esprit de corps* of the men are splendid, largely by reason of the excellent provisions for the subsistence of the employees and the healthful conditions under which they all live and work.

Colonel Goethals and his whole force deserve great credit for the splendid manner in which the work is being prosecuted, and in it they should have the hearty support of the entire nation. It is a big job, handled by big men, in a big way.

W. E. C. EUSTIS, Boston, Mass.—If the canal is considered from a commercial point of view, then the important question is, how the American people, who have furnished the money, can reap any benefit from it. If it is desired to furnish a route between the eastern and western coasts of the United States, which will give cheap transportation, it seems imperative that the United States government should, in some form or other, operate a line of steamers through the canal; otherwise, there will be nothing to prevent the transcontinental railroads from buying up the steamship-lines operating between the two coasts, and fixing the rates at such a figure that the business will continue to be carried by the railroads. We have had experience with such matters in New England. Many of our coastwise steamship-lines are owned by the railroads, and rates quoted by them between Boston and Norfolk, for instance, are the same as the all-rail rates; the steamship company even going so far as to quote in "carload lots." What is to prevent the great transcontinental lines, with their command of huge sums, buying up the stock of any steamship-line they wish? There will of course be a great hue and cry over the United States government operating a line of steamships, but what other remedy will there be in the matter?

CHARLES W. GOODALE, Butte, Mont.—The adoption of the plan of a lock-canal, in preference to the sea-level canal, has effected a great saving in estimated time and outlay, and if the present plan should be found to involve, by reason of landslides and other causes, a greater expenditure than was calculated, the sea-level design would have had at least the same proportional unforeseen difficulties and outlays.

In the Gatun lake provision is made for receiving and settling in still water, and at such a distance from the channel that dredging will certainly not be an important item in the cost of operating, the sediment brought down by the many streams which flow towards the canal channel; while with a sea-level canal it would be impossible, even with a large outlay for diversion-channels, to prevent the deposit of much sediment in the canal, with consequent dredging-costs.

C. B. HOUCK, Hazleton, Pa.—A sea-level canal, on account of the tremendous cost involved, together with the necessity of harnessing the Chagres River and fifteen or twenty other streams, not to mention the additional length of time necessary to complete the canal, and the high cost of maintenance, seems to be absolutely out of the question.

The maintenance of the present lock-canal will naturally be high for a year or two after completion, especially in the Culebra cut, where dredging will be necessary because of the treacherous nature of the ground, but the angle of rest will finally be disclosed, and no more danger of slides, etc., need be feared.

The concrete work at Pedro Miguel and Miraflores on the Pacific side, as well as at the Gatun locks on the Atlantic side, is certainly being pushed rapidly; and the cost of concrete in place, averaging as it does $5.35, is lower than the average cost in the States.

HENNEN JENNINGS, Washington, D. C.—The most uncertain work yet to be done to complete the canal is the further excavation of the Culebra cut. The rock in this cut is largely of mixed and complex igneous varieties, easily decomposing, and subject to caving and sliding. In the estimates made, margins have been allowed for the probable extra material to be handled on account of these factors. At worst, it is only a matter of more digging and time. Of course, the deeper the cut the more serious and extensive would be the danger and difficulty of dealing with such a class of material.

In view of the character of the material to be dealt with, a deepening of the Culebra cut by 85 ft. for a sea-level canal did not appeal to me as an inviting task. It is my belief that, even now, with the vast accumulated data supplied by the past work within the Canal Zone before him, no engineer could make an estimate of the cost of a sea-level canal which could be seriously relied upon. No doubt the mighty resources of the United States could put such a project through, if patience and time were also bountifully provided. But I fail to see what extra benefit could be derived from it.

WILLIAM KELLY, Vulcan, Mich.—A great deal of the rock in the Culebra cut breaks up and slides down from the sides, with a very low angle of repose. Every

additional foot of depth, therefore, means a very great increase in the quantity of material to be excavated. The dam at Gatun raises the water in the canal approximately 85 ft. above sea-level, and by so much diminishes the excavation.

The question has been raised, whether a higher level for the canal through the Culebra cut could have been adopted, to diminish still further the amount of excavation, and thereby reduce the total expense. The data required to consider this question with accuracy are not at hand; but some of the features of the topography are sufficiently pronounced to show that a canal at a higher level would require very large expenditures for construction, counterbalancing either wholly or in a very large part the saving in excavating, and involving a considerable increase in the cost of operating and the time of passage.

I am, therefore, thoroughly satisfied that the 85-ft. level is the most economical level that could have been adopted, and the one which will make the most satisfactory canal across the Isthmus of Panama.

WILLIAM KENT, Montclair, N. J.—I have recently been defining engineering as the science and art of overcoming the resistances of nature, including human nature; and the accuracy of this definition is exemplified on the canal. No matter how perfect may be the plan of such a great work, how careful the preparation and how good the equipment, the work will not be done to the best advantage if there is not a good organization and a good man at the head of it. The difficulties of building up and managing such an organization are here intensified by the climate and by the distance from home; and the finding of the man to be at the head is of the utmost importance. I regard the discovery of Colonel Goethals as the best man to complete the work that was so well planned and begun by his predecessors as comparable to the discovery, by President Lincoln, of General Grant as the best man to finish the Civil War. Colonel Goethals is unquestionably the right man in the right place. I hope that after the canal is finished, some one of the engineers connected with the work will write a book showing how Colonel Goethals did the work of overcoming the resistances of human nature. Such a book, properly written, would be an inspiration for the coming generation of engineers.

W. A. LATHROP, Philadelphia, Pa.—I was particularly impressed during our visit to the Canal Zone:

1. By the wisdom of the conclusion to construct a lock-canal instead of a sea-level canal, notwithstanding the very strong popular prejudice in favor of the latter type.

2. By the completeness and efficiency of the organization under Colonel Goethals, and the energy and enthusiasm with which the work is being carried on, in the face of very trying climatic conditions.

3. By the effectiveness of the sanitation in the Canal Zone and the included cities of Colon and Panama.

While the idea of a sea-level canal, with a wide waterway—a veritable "Straits of Panama"—naturally appeals to the imagination as a magnificent and desirable national undertaking, nevertheless a sober consideration of the existing topographical and hydrographical conditions, especially in the light of the actual experience gained in the work which has been accomplished to date, must convince any engineer who now approaches the subject with an open mind, that a sea-level canal is impracticable, except at a cost out of all proportion to the benefits to be expected through the construction of a canal across the Isthmus.

J. GIBSON McILVAIN, Philadelphia, Pa.—Judging from the physical and topographical conditions as I saw them on the Isthmus of Panama, I do not think it would have been at all practical to build a sea-level canal.

I regard Colonel Goethals as one of the ablest men I ever met for such a job; and if the people of our country will back him and his fellow-commissioners we shall have cause to be as proud of them as we are of Washington, Lincoln and Grant.

I was a close observer of the laborers at work. Every gang of men I watched had a good man in charge, who understood his work; and he and his men were working to get done, and not merely to draw their pay from Uncle Sam. The Canal Zone is no place for loafers. The whole work is well organized—for which great credit is due to those in charge of it.

The magnitude of the undertaking, the sanitary conditions, and the systematic, hustling way in which the whole work is being carried on, thrilled me with greater pride in our flag than I ever felt before.

F. P. MILLER, East Downingtown, Pa.—Those of us who favored the lock-canal, at the time when that type was adopted, could not understand, after reading the reports of the committees who visited the Isthmus, how so many eminent engineers could favor a sea-level canal, and now, in the light of later experience, and in view of the wonderful progress and present condition of the work, that feeling is confirmed.

THEODORE H. MILLER, Poughkeepsie, N. Y.—My ideas before visiting the Panama canal were probably not very different from those of the majority of the members of our party. I was prepared to see a force of men working at perhaps anything but a rapid pace, on account, of course, of the tropical climate and other conditions, and was therefore, very agreeably astonished to find the vigor and "snap" which was evident on all sides. Colonel Goethals and his very able chief lieutenants have instilled this "ginger" into the working-force.

At this time, and with the work now so well advanced, the discussions of some two years ago in regard to the relative merits of a sea-level or lock-type canal are nothing short of amusing. It is now plain, even to a novice, that the best practicable plan has been adopted, and that no other is worthy of serious consideration.

R. V. NORRIS, Wilkes-Barre, Pa.—In view of the conditions as we saw them, it seems to me that a lock-canal is undoubtedly the correct solution of the problem of a navigable waterway across the Isthmus of Panama. The avoidance of excavation in the soft swamps between Gatun and the Culebra cut; the effective control, not only of the Chagres River, but of the 30 or more smaller streams which enter the canal-prism; the avoidance of deeper cutting in the Culebra cut; the possibility of making the huge fresh-water Gatun lake; and the economical enlargement of the canal to a channel 1,000 ft. wide for over half its length, are, to my mind, conclusive arguments in favor of a lock-canal.

The Culebra cut shows at present great instability of material, evinced by the huge slides which have already taken place, and which will undoubtedly be followed by others, until the material has reached its natural angle of repose. The additional excavation due to these conditions, while serious, is by no means insurmountable; but no one would be willing to predict the amount of additional excavation which would be involved in going 85 ft. deeper than is now proposed. Even assuming the successful establishment of efficient control of the Chagres and other streams—requiring large dams on doubtful foundations, and diversion-channels which would probably be ultimately as large as the canal itself—it would seem to me hardly practicable to keep open a canal-prism 45 ft. below sea-level through the huge soft swamps between Gatun and the mountains, without continuous and very expensive dredging—and even this would not, to my mind, certainly secure permanent success.

I made some careful investigations as to the cost of excavating rock under water and found that the experience on the canal, under the most favorable conditions, showed a cost more than twice as great for under-water excavation as for the same material dry.

There is no doubt in my mind of the completion of the canal by January, 1915, the date set for its opening, or even considerably before that time; and it is my emphatic opinion, in view of the present conditions, that a sea-level canal, if it could have been built at all, even with the narrow channel originally proposed, could not have been completed for many years to come, and would have cost so much more than the present lock-canal as to make its completion problematical.

WALTER T. PAGE, Omaha, Neb.—In the sea-level type, the sediment from the flood-waters of 24 rivers would have had to be taken care of. The slides on both sides of the great Culebra cut are formidable even at the present depth; and with the much deeper cut to sea-level it would, I believe, be impossible to compute their magnitude or the cost of their removal. The work already done in the cut has thrown much new light on the subject.

ROSSITER W. RAYMOND, New York City.—Many of us have felt surprise that eminent engineers should have favored a sea-level canal; but, as we have said in our collective statement, new light has been thrown on the subject. In my judgment, the recommendation of a sea-level canal was originally based on the feeling that the United States, being rich enough to pay for the best, ought to have it at any cost. And the estimates of the extra cost of the sea-level canal seem to have been based upon a simple calculation as to the additional amount of excavation. I think the new light since thrown upon the subject may be classified as follows:

1. Experience in railroad work, surveys, etc., has increased the grounds for fear that a navigable channel through the swamps of the Gatun basin would be tortuous and shifting, and could be kept open only by an amount of continual dredging which would diminish the effective capacity of the canal, while greatly increasing the cost of its maintenance. In other words, it is now by no means clear that for at least half of the total distance from deep water to deep water, a sea-level canal, dredged through a swamp of this character, would be "the best thing." It seemed to many of us that the opportunity to meet this difficulty by putting 85 ft. of water over this swamp, instead of dredging a narrow channel through it, was a providential way of escape from many other difficulties at the same time.

2. In the same connection, recent experience has shown that the Chagres River does, in fact, during floods, bring down large quantities of heavy material (gravel and boulders) as well as finer silt, so far as to affect seriously a dredged channel, which it would meet at right angles. This was formerly denied, or regarded as something easily to be prevented by auxiliary works of protection. Our observations of recent flood-effects of this kind indicate the contrary.

3. Experience has shown that the cost of excavation for a sea-level canal, as compared with that of the present plan, would not be proportional to the relative amounts of excavation required according to the cross-section of the proposed prism. The slides encountered in the Culebra cut, which have already greatly increased its cost and delayed its completion, indicate but faintly what might be expected in an attempt to carry that cut 85 ft. deeper.

The material through which the Culebra cut has to be made is exceptionally treacherous, being a complex of sedimentary and igneous rocks, liable to slide on each other, and highly decomposed besides. It is impossible to calculate with accuracy beforehand, just what will be the behavior of such material, or what will be its final angle of repose. The best evidence, in such a case, is the opinion of mining engineers, who have had to deal with similarly treacherous ground. Our party contained not a few such experts and their unanimous opinion was, that the Culebra cut could be completed to the proposed depth, within the Commission's estimate of cost and time; but that the feasibility, cost and duration of the attempt to make it 85 ft. deeper could not be estimated.

The new light which forbids any estimate as to a deeper cut is, I think, aside from the behavior of the walls of the present cut, the development of the existence, below its proposed bottom, of a thick bed of plastic material, subject to horizontal movement by what we miners call "squeeze." Messrs. Gardner F. Williams and Hennen Jennings, through their experience in hydraulic mining, and many of us, who, in the management of collieries, etc., have encountered the effect of "creeps" and "squeezes," can appreciate this condition, and agree with the statement of Mr. Williams—which I, for one, on the strength of my own observation, fully accept—concerning its effect. It amounts to this: that the effect of vertical pressure upon such a plastic layer, causing it to move horizontally towards any opening cut in it, may extend to the distance of a mile; that such a movement might, in this case, so fissure the overlying ground, thereby causing it to sink, as to extend indefinitely the zone of material liable to be washed into the Culebra cut. In such a case, the question becomes one, not of the "angle of repose" of a given mass of material, but of its behavior when, already fissured, as well as disintegrated by weathering, it is traversed by torrents of water. I think this "new light" would convince any prudent engineer, as it convinced us, that we are fortunate in having found a plan which does not require the deepening of the Culebra cut below the level now contemplated.

4. But new light has been obtained also upon certain doubts and objections concerning the details of the proposed lock-canal. As to the impermeability of the Gatun dam, evidence has been furnished by the storage-reservoirs for the water-supply of Panama, Colon, etc., constructed in the hills of similar material, and still more recently, by the small lakes or pools which we saw lying against the embankments of the relocated Panama railroad. In these cases, material similar to that of the Gatun dam, and of some of the natural hills, bounding the proposed Gatun lake, which have been under suspicion, has proved to be practically water-tight.

During and after my visit to Egypt in 1901, I had the honor of being consulted by the Secretary of State, the eminent English engineer, Sir Colin Scott-Moncrief, who was then considering the project of the great dam at Assuan on the Nile, as to whether the hydraulic head of that reservoir might not simply, through increased seepage, reinforce unnecessarily the water-supply of some of the oases in the Sahara, instead of benefitting Egypt proper. In reply to this inquiry, I sent, together with sundry published reports of American practice, the confident personal assurance, based upon my knowledge of such enterprises in the West, that, in my opinion, any muddy river, like the Nile, would speedily "puddle" and render practically impervious the walls of any reservoir or ditch into which it flowed. What I then thought of the Nile, I now think of the Chagres.

In one sense, the whole discussion of the best type of canal is now purely academic; that is to say, the present plan being evidently practicable, and the work of its execution being evidently in progress to an early completion, no one would now seriously propose a change. Yet it is not purely an "academic" thing to satisfy the American people that this great work is now being executed in the best possible way, and that a change would not be desirable, even if it were practicable.

PROF. JOSEPH W. RICHARDS, South Bethlehem, Pa.—Like many others of this party, I came on this trip thinking that a sea-level canal was, of course, preferable to a lock-canal, but that it would cost so many millions of dollars more that it was not worth the difference. I am now firmly convinced, for many good and sufficient reasons, that a sea-level canal, even if it were possible to build it and to keep it in operation, would be less desirable than the lock-canal. In other words, irrespective of the cost, the present canal is preferable to a sea-level canal. It is difficult to understand how any engineer could, at the present time, maintain the contrary proposition.

D. M. RIORDAN, New York, N. Y.—One engineer of our party, whose work involves large removals of "overburden," told me he had never seen anything of its kind so adequate and so perfect. Nowhere was a laggard to be seen. Nowhere could the most practiced eye discover a slow motion or a false one. In railroad phraseology, the "slack" seemed to be all "taken up."

The work being done on the canal is not only the best it seems possible to do, with our present knowledge of methods and tools, and under the existing local conditions. It seems quite up to the best standards of practice in similar work anywhere. Some of it apparently holds the world's record, as to both output and lowest cost per unit of performance. We may properly find in this situation something of which we may well be proud, not only as engineers, but as Americans.

THOMAS ROBINS, New York, N. Y.—On the Isthmus, the work of the sanitary and railroad departments seem to me to be especially good; but the one feature that stood prominently to my notice, was the wonderful *esprit de corps* and the genuine interest in the work which pervades not only the men who are actually employed, but their families as well. The entire population of the Isthmus is inspired by that combination of energy, ability and justice which makes Colonel Goethals a real leader; and each man seems to realize that while his very best work is demanded, it will also be appreciated. As the first Chief Engineer who has "made good" on this job, Colonel Goethals deserves the hearty support of the people of this country. We should feel proud of him and of the work that is being done both by our soldiers and our civilians on the Isthmus.

D. B. RUSHMORE, Schenectady, N. Y.—A national work of great magnitude, presenting many difficult problems, is evidently being executed with skill, economy, and expedition. One can compare it with the excellent work done by our Reclamation Service. It leaves no doubt that, with proper organization, our government is fitted to carry on enterprises of this kind. Whatever may have been former opinions formed without the full information now at hand, there appears to be no doubt at present that a sea-level canal would be both undesirable and impracticable.

An electrical engineer is surprised at the small part which electricity is playing in the construction of this enterprise. Had it been possible to develop the water power of the Chagres River and to distribute this power over the line of the canal, a large proportion of the work could undoubtedly have been done more conveniently and at a considerably reduced cost. If the work were to be planned over again, there is but little, with the exception of the small air drills, which could not be better and cheaper done by the use of electric power. Such power is to be largely used after the completion of the canal. The electric power houses at Gatun and Miraflores are models of their kind, and the use of electricity, so far as it has been applied, shows very careful engineering. The climatic conditions are such that special features in connection with the insulation of electrical machines are necessary or desirable.

Every effort should be made to acquaint the American people with this great work, which is being so well carried on by their government; and we should all have a feeling of pride both in the enterprise itself and in the way in which it is being constructed.

W. L. SAUNDERS, New York, N. Y.—The present condition of the Panama Canal work affords ample evidence of the wisdom of those who planned it as a lock canal. If we agree that the best engineering is that which accomplishes a result in the most economical manner, we must admit that this design has been based on good engineering. It is also good business to build a lock canal. No one, when asked to assist the government in planning an enterprise of this nature, should draw any distinction between what is best for a government and what is best for a corporation or an individual. That there is plenty of money behind the scheme is no reason for recommending a plan which involves a cost greater than some other plan.

Now that the excavation on the Panama Canal is about three-quarters done, we realize the dangers of deep excavation in the Culebra cut. The slides are greater than was anticipated by any of the engineers; and no one can tell what might happen if this cut had to be made 85 ft. deeper.

The Chagres River also has given us evidence of its dangerous power to affect the prism of a sea-level canal. We have seen hundreds of thousands of yards of material, mostly in the nature of pebbles, brought down by the floods and deposited in deltas almost on the line of the canal. It does not take the imagination of an expert to see that this material might almost completely obstruct the channel of a sea-level canal.

It is plain that we owe much to the French for the present condition of the canal. Not only did they perform a great deal of excavation which will be used, but in engineering and in plant the French have placed us under obligations. We have seen the old French dredges at work; and little criticism can be made of them except that they are small. The dump cars, locomotives, and other apparatus left by the French can only be criticised on the same ground—that they are too small for the work. Yet at the time they were purchased they were of the maximum size for this class of work. The material, such as roofing, furnished by the French, stands to-day, while much of the material purchased in the United States has deteriorated.

CHARLES SEWELL THOMAS, JR., Denver, Colo.—From the beginning of the work on the Panama Canal I have been greatly interested in it, and have devoured with avidity the various newspaper and magazine articles that have appeared, either descriptive of it or critical of the methods used and the men using them. As a whole, these articles have tended to create an impression that a lot of incompetents were trying to achieve an engineering impossibility. It was with great pleasure that I found this impression dispelled through the opportunity afforded me to visit the canal in person and to talk with the men who have been so severely criticised; and it is an additional pleasure to testify that I can comprehend no motive that should impel a sane person to indulge in aught but praise for the efficiency and speed with which the work is being done.

I can only reiterate, therefore, that the canal is not only an engineering possibility, but that it is an engineering practicability; that the lock-canal system is not only the best style that could be built in Panama for every reason, but that I consider the sea-level type an economic impossibility; that the perfection to which sanitation has been brought on the Isthmus is nothing short of marvellous; that the handling of material by the Panama Railroad is as rapid and efficient as possible; that the placing of concrete at Pedro Miguel, Miraflores and Gatun sets a new record for quantity, speed and cost per yard.

MICHAEL TRACY, New York, N. Y.—I confess that I went to Panama with the firm conviction that the only canal that should be built was a sea-level canal; but after a thorough personal inspection of the conditions, I think that the lock canal was the only feasible canal that could be built to meet the conditions that existed on the Isthmus.

After viewing this gigantic piece of engineering, it seems to be that too much credit cannot be given to the men who are building it. They are entitled to all the support and encouragement that the citizens of the United States can extend to them.

Having been accustomed for the last twenty-five years to handle large numbers of men, I was much impressed by the excellent organization of labor on the Isthmus, and the extraordinary efficiency which it develops in every man, from the foreman to the laborer—all doing their parts with the precision of a great machine. I shall advise some of our large New York contractors to take a trip to the canal before it is completed, and I believe that they can learn from that work a few things about management which would amply repay them.

JOSEPH UNDERWOOD, Roscoe, Pa.—I have inspected the work on the great Manchester Canal in England; watched the building of the great jetties at New Orleans under the supervision of Captain Eads; pondered long over the locks and dams that augment the commercial value of the Seine, France; studied the wonderful canal and locks at the Ste. Sault Marie that open the vast Northwest and complete transportation on our Great Lakes; but in all this there was nothing which impressed upon my mind so vivid a sense of wonderful achievement as I have received from the work now in progress under competent engineers on the Isthmus of Panama.

From a scientific standpoint and from the standpoint of good common sense, the abandonment of the plan to make the canal a sea-level waterway was a good thing. It is true that the building of the great Gatun and Pedro Miguel dams and locks is an onerous and costly task; but with their completion it will be demonstrated that better service and a surer channel will be afforded.

FRANK M. WARREN, Minneapolis, Minn.—Before our visit to the Canal Zone, the paramount question in my mind, and in the minds of some others of our party, was, "Is the lock canal now building better than would be the proposed sea-level canal?" After a week of inquiry, observation and close examination, in which we were aided in every way by all with whom we came in contact on the work, I am convinced that this question should be answered in the affirmative.

I believe that, with an amount of money beyond reasonable limits, the proposed sea-level canal, with a width of 100 ft. at the bottom of the prism, could be built—but what then?

At the northwestern end of Culebra cut, and just below Gamboa, the Chagres River channel encounters that of the canal at right angles, and the two channels are from there practically coincident for over 20 miles to Gatun, where the river, having crossed the canal, flows northwest into the Atlantic.

On Nov. 7, when our party visited the Gatun dam, it arrived just after a rainfall of 3.28 in. in 50 minutes. By considering the rainfall of from 60 to 120 in. per annum, on the Isthmus, and the maximum measured annual fall of 240 ins. recorded (at Porto Bello) on the Atlantic coast, some notion of the floods to be expected may be gained.

It is possible to build a dam just above where the river channel meets that of the canal, which would give a storage area of nearly 4 sq. miles at 85 ft. elevation; but this would only in part care for the floods which at times raise the Chagres River more than 30 ft. above normal; and the balance of the water entering the narrow canal would create such currents that large vessels, filling over half of it, would be utterly unmanageable.

In such a narrow channel the larger ships could move but slowly; and the capacity of the canal would be limited by their speed. Turnout places would be necessary, and boats would have to run on schedule and wait at such places, losing much time, as occurs with heavy traffic on a single-track railroad. The wash of the larger steamers, crowding the capacity of the canal, would cut the banks, causing caving and filling, which would require continual heavy expenditures for repairs.

Possibly a greater immediate menace to the sea-level plan than even the Chagres River is the 9 miles of deep excavation, known as the Culebra cut.

Drilling in the bottom of the canal as now proposed, with a water level of 85 ft. above tide, shows that beneath the rock in which the prism is now being cut is a layer of about 40 ft. of a blue material, of the consistency of clay. Were the canal prism as now planned to be lowered 85 ft., or to a depth necessary for the sea-level plan, it would cut through this soft layer, leaving it open and exposed on the sides of the prism. The weight of the hundreds of feet of superimposed rock on both sides of the cut would squeeze this material out into the prism as fresh mortar is squeezed from between two courses of brick. This extruded material could be removed; but the hills above it would be so seamed and shattered by the giving way of this layer that slides would be constantly moving down into the canal during each wet season, and the amount of material to be removed would be stupendous.

One must go far to find rock and dirt trains traveling as fast and as close together as they are daily doing in the Canal Zone. The tracks are well located, enabling high efficiency of execution of the steam shovels, especially in view of an eight-months' tropical wet season. The engineering problems are not those of difficulty so much as of immensity, and with an *esprit de corps* so excellent and a force so efficient, an early completion of the canal is the logical result.

GEORGE H. WARREN, Minneapolis, Minn.—Accustomed for years to see somewhat similar work in moving even vaster quantities of earth, rock and ore on the Mesabi Iron Range in Minnesota, the writer was to make comparisons of methods, organization and the use of labor, while necessarily bearing in mind the great difference in original conditions between the Isthmus and that part of Minnesota north of Lake Superior.

The organization on the Isthmian Canal seemed everywhere well-nigh perfect; and the unit of labor secured per man could not be easily increased. Workmen engaged in operating churn drills, air drills and steam shovels, or as track layers, track shifters, shovelers, quarrymen, loaders and unloaders of cars, trainmen, linemen, mixers of materials for concrete—in fact, everywhere that a man or a group of men could be seen, whether in rain or in sunshine, that man or group of men was apparently doing full duty. So admirable is Colonel Goethal's organization and control of affairs, so thoroughly has he succeeded in awakening an interest in the great work of constructing the canal, in the best manner and in the shortest time possible with good work, that every chief of a division, every superintendent, every foreman of a crew seems to act upon the principle that it is his work which is to accomplish the final result.

I believe the unanimous opinion of the visiting members is that a lock and dam canal is the only feasible way of building an interoceanic canal on the route selected.

It would have been impossible to prosecute the work to a satisfactory finish except under the control of the War Department.

R. B. WATSON, Cobalt, Ontario, Canada.—The Culebra cut is the uncertain part of the whole undertaking; and I do not believe that the canal engineers or anybody else can estimate even approximately how much material will slide into the excavation by the time the final depth is attained, and the sides have found their final angle of repore.

The problem would have been comparatively simple had this excavation been in hard rock; in this case, however, the excessive heat and moisture, and the nature of the material, have resulted in a decomposition of the rock to the full depth of the cut. This condition permits of cheap excavation, but leaves bad sides, full of soft slips, always feared by the miner. This, however, will gradually work itself out as the work progresses; there is nothing to do but let it slide and carry away the material, which is a comparatively simple matter.

The hydraulic plant below the Miraflores locks has just been started, so that no reliable cost per yard of excavation could be given at that time. The object of this installation is twofold: one is to excavate a section of the canal by jets of water from monitors; the other is to obtain puddled material to fill in the Miraflores dam. The 300-ft. head of water for the monitors is obtained

by a large installation of reciprocating pumps, situated close to sea level. The streams from the monitors are directed downward into the canal section and wash the material into sumps, from which it is drawn by suction pumps and run into the dam. My impression of this arrangement was, that it was not as good as that employed at the Gatun dam, where a suction dredge is taking the materiali from the bottom of Gatun Lake and pumping it over to fill in the center of the dam.

The advisability of trying to excavate clay by a hydraulic jet, in a cut below the level of the monitor, and where there is not much grade to carry the material quickly away, appeared doubtful to me.

HUGO WEINBERGER, Vienna, Austria.—In my native country it has become customary to call America "the land of unlimited possibilities." Over there, also, the limits of the possible would be far, far extended, if many things were attacked and performed in American fashion; for American methods bear the stamp of the logical and the necessary as truly as American achievements.

I count myself happy to have enjoyed, through the inspection of this canal construction, the opportunity to observe the American in an undertaking permitting the free exercise of his energy and enterprise. There can be no doubt that he will carry to a successful completion this greatest construction of the world.

GARDNER F. WILLIAMS, Washington, D. C.—The most important piece of work on the canal is the Culebra cut, which, in my opinion, is the key to the whole canal system.

The question of a sea-level canal was discussed by us at considerable length; and we were all of the opinion that a canal with locks is the only one practicable, considering the nature of the ground through which the Culebra cut is being made. The hills are composed to a great extent of sedimentary and volcanic rock in a decomposed or weathered state. Much of the rock slakes upon exposure to the air like the shales from coal mines. The rock in place contains soapy seams or seams of clay. In the Culebra cut large slides of earth and rock occur, which reach back into the hills far beyond the surveyed lines of the canal prism. It is impossible, in my opinion, to estimate the distances into the hills to which the slides may extend, or make any reliable estimate of the quantity of ground which would slide into a cutting deep enough to make a sea-level canal. Judging from existing conditions, it seems to me that it would be almost impossible to dig and maintain the Culebra cut deep enough for a sea-level canal. Even if it were possible, it would take so long a time and the cost would be such an unknown quantity that engineers visiting the Canal Zone during the present time would hesitate to advise the sinking of the Culebra cut 85 ft. deeper than the plans now call for.

The question of the angle of rest at which ground such as is met with in the Culebra cut, situated in a country where the rainfall is abnormally great, will cease moving, is one that cannot be determined by any known engineering methods. My experience, gained from observation of moving masses of ground in some of the hydraulic mines of California, has shown that ground has been known to move hundreds of yards, and in one case nearly a mile on the channel of an ancient river bed when the fall was not more than 1 ft. in 12. With the unknown factor of safety of ground resting upon soft clay or of rock traversed by soapy seams, accurate calculations of the quantity of ground that may slide into the Culebra cut cannot be made.

Therefore, viewing the canal at the present time with the difficulties which have been brought to light in this cut, I agree fully with my brother engineers, with whom I visited the Canal Zone, in the opinion that a lock canal is the only one feasible, when the cost of construction and the time it would take to make a sea-level canal are taken into consideration.

Just a word on the sanitary condition of the Canal Zone. Nothing surprises me more than the absence of mosquitoes and flies. I did not see a mosquito during the week we were on the Isthmus.

The white men looked healthy, and none showed that yellow, bloodless color so often met with in tropical countries where malaria exists. The work done on the Isthmus to ameliorate its former condition and make the zone healthy is really marvellous.

GOOD PROGRESS IN SECURING THE ADOPTION of standard hose couplings and hydrant fittings for public fire service is reported by a special committee of the National Fire Protection Association. The committee has issued an extensive list of cities which have adopted the "National Standard Hose Coupling" and a supplementary list of places in which couplings not complying with the standard may readily be adapted for service in connection with the standard. The committee has also issued suggestions for the extension of standardization. Copies of two bulletins dealing with this subject can doubtless be obtained by applying to Mr. F. M. Griswold, Chairman, Standard Hose Couplings Committee, National Fire Protection Association, 56 Cedar St., New York City.

The New Water-Supply Tunnel Under New York City.

In our issue of Dec. 9, 1909, p. 652, we described briefly the deep rock distribution tunnel which is proposed to carry the water-supply of the City of New York from the new Hill View reservoir just outside the New York City limits in the city of Yonkers down through the Boroughs of the Bronx and Manhattan under the East River to the Borough of Brooklyn, and thence by a pipe line into the Boroughs of Richmond and Queens. Since that time, the proposition has been approved by all the necessary state and city authorities upon the favorable reports of all the experts engaged to investigate the scheme.

The Board of Water Supply has therefore been preparing extensive plans for the work, and bids upon most of the sections are to be opened on May 16. The contracts now under consideration are four in number, comprising the entire line of tunnel proper, extending from the reservoir in Yonkers to the tunnel shafts near Fort Greene Park in Brooklyn, from which point the further continuation of the conduit is to be in pipe line. The contract is a very extensive one, calling as it does for a tunnel over 93,000 ft. long, varying in diameter from 15 to 11 ft. and in depth below the surface from 200 to 750 ft. under the city. There are also some interesting features of the contract proper which deserve to be set down.

The tunnel is to serve as the main distribution system for the 500,000,000 gals. per day supply of the new aqueduct. This distribution is to be made through 23 uptake shafts located at average intervals along the line, in nearly every instance in some park space owned by the city where surface work will not interfere with business or traffic and where no extra expenditure for space need be made for the contractor. These uptake shafts are to be built first as construction shafts, from which the tunnel will be driven, but after the tunnel is finished the shafts will be used to hold the uptake pipes, which will be placed in the shafts and lined with and encased in concrete, and the pipes will be controlled from the surface by specially designed valves at the juncture of the main tunnel and the vertical riser. One construction shaft in addition to these 23 is to be built near the northern end of the tunnel and will be subsequently filled with concrete when the tunnel is completed.

The following table shows the lengths and sizes of the tunnel in the four contracts which are to be let soon:

No. of contract.	Length, ft.	Diam. conduit, ft.	No. shafts.	Depth of shafts, ft.
63.....	21,260	15	5*	215-240
65.....	17,700	14	7†	260-475
	10,600			
66.....	15,590	14	6	200-250
	4,540	13		
	2,990	12		
67.....	6,000	12	6*	310-740
	15,000	11		
	93,840		24	

*One construction shaft.
†One drainage shaft.

It will be noted that the total length of the tunnel is 17.7 miles, divided nearly equally among the four separate contracts. It will also be noted that of the 23 shafts two are drainage shafts. These are placed at two low-level places on the line of the tunnel; one where the tunnel starts to rise again from the drop which is necessarily made at the soft ground underlying the Harlem River, and another at a similar location on the east side of the drop made at the soft ground at the lower end of Manhattan Island. Both of these sumps are shown on the original drawing which we reproduced with the article noted above.

The tunnel is to be driven throughout through the gneiss, schist and limestone formations underlying the city. The position and condition of these formations have been carefully investigated by the geological consultants to the Board of Water Supply and the results of their studies are offered to the contractor for his information. These studies consist mainly in a large number of borings, together with the opinions of the geologists upon the geological nature of the ground. The Board of Water Supply does not advance any of this information as authentic, but gives it to the contractor for what he may consider it worth.

The tunnel is to be throughout a concrete-lined conduit varying in diameter from 15 to 11 ft. Several different designs are proposed, depending upon the nature of the rock through which the tube is to go, but in general the section is a circle, of the interior diameter noted, with a thickness of concrete lining of about 15 in. The shafts are of 14 ft. interior diameter carrying a 4-ft. diameter uptake pipe. Special provision is made for the backing of the tunnels in case soft rock is encountered, and the air-mixing grouting machine used successfully in the Rondout and other up-state tunnels by the Board is recommended to be used for similar work on this tunnel.

In spite of the extensive exploratory geological work which has been done for the tunnel, the great depth at which it must be driven prevents any accurate knowledge of the conditions which are to be made, particularly in regard to the water-bearing properties of the rock. On this account, the contractor is protected against any unexpected water flow by the following novel clause in the contract:

> The contractor shall receive the stipulated price per million gallons raised one foot. The measurement of head pumped against shall not include friction losses in pumps or piping, nor losses due to pumping in two or more stages, but the head shall be measured from the average level from which the first pump engaged in pumping the water in question takes its water, to a reasonable elevation of the final discharge point for the water.

On account of the proximity of the heads of the shafts to the traffic and residences of the city, the contract requires that only electric pumps be used. In connection with this item, the contract carries a letter from the New York Edison Co. quoting the following rates which they agree to charge for electric service to the pumps:

High Tension Alternating Current:

> For alternating current supplied directly from our Waterside Stations—to all shafts in The Bronx and on Manhattan Island—6,300-6,600 volts, 25 cycles, three-phase—$20 annually for each KW. of maximum demand and 1 ct. a KW.-hr. for the current actually consumed as recorded by the Company's meters.
>
> It is desired that the motors be constructed for 6,300 volts; attention is drawn to the fact that we now propose to supply a uniform standard of 25-cycle current throughout the entire system.

Low Tension Direct Current:

> Where it will not be convenient or practicable to use high tension current for these purposes, low tension current will be supplied at a rate of 2½ cts. a KW.-hr. for the current actually consumed as recorded by the company's meters, as follows: (1) In the Borough of The Bronx and for two shafts north of 136th St., 120-240 volts, 2-3 phase, 25 cycles alternating current; (2) on Manhattan Island, south of 136th St., direct current, 120-240 volts.
>
> Should any contractor south of 136th St. desire 25-cycle low tension alternating current, arrangements could be made to render service of that class.
>
> The prices quoted are for current, delivered at each of the 24 shaft sites. At these points meters are to be installed, from which the responsibility for the use of the service will rest upon the contractor.

As a further protection against the uncertainties of the work the following clause is inserted in the instructions to bidders:

> In the case of grouting, owing to the uncertainty as to the quantity, distribution and conditions of placing the grout, to the special character of the machinery required and to the great importance of this work, the machinery and materials and the various necessary operations will be paid for under separate items.

Finally, another important clause of the contract reads as follows:

> The contractor shall take all responsibility of the work, shall bear all losses resulting to him on account of the amount or character of the work, or because the nature of the land in or on which the work is done is different from what is assumed or was expected, or on account of the weather, floods or other causes; and he shall assume the defense of, and indemnify and save harmless, the City and the Board, and each member of the Board, and their officers and agents, from all claims of any kind arising from the performance of this contract.

Bids are asked entirely on separate items, 64 of which are listed, for instance, in contract 67.

A FIRE IN THE TIMBERING of the Hartford mine of the Republic Iron & Steel Co., near Negaunee, Mich., May 5, caused the death of seven men.

A THEATRE FIRE IN EDINBURGH, Scotland, May 9, caused the death of seven persons, none of whom, however, were in the audience. The fire started on the stage, where it was confined temporarily by the prompt lowering of the fire curtain, although the whole building was eventually destroyed.

A STEAM MAIN EXPLODED May 4 on the steamship "State of Ohio" while the vessel was being overhauled and repaired in the Cleveland harbor in preparation for the initial trip of the season. Eight men at work in the cabin above the boiler room were badly scalded. The "State of Ohio" is a passenger boat owned by the Cleveland and Buffalo Transit Co.

A ROUNDHOUSE FIRE at Benton Harbor, Mich., April 24 destroyed several locomotives, causing damage estimated at $300,000. The house was the property of the Cleveland, Cincinnati, Chicago & St. Louis Ry.

At Sioux Falls, S. Dak., April 25, fire destroyed the shops and roundhouse of the Dakota & Southwestern Ry. Reports state that several locomotives were lost.

FOREST FIRES IN NEW ENGLAND have burned over several thousand acres of timber land during the past two or three weeks. Maine, Connecticut, Rhode Island and Massachusetts are the states in which the more extensive fires occurred. The most serious fires reported were in the vicinity of Biddeford and Sanford, Me.

Extensive fires have been reported also along the Magothy River in Maryland, and in the Catskill Mts. in New York.

THE DERAILMENT AT MARTIN'S CREEK, N. J., April 29 has been ascribed by the verdict of a coroner's jury to "a defective roadbed." The verdict charged no one with negligence, but according to press reports, the evidence submitted at the inquest tended to show that the engineer of the wrecked train, a "special," was not informed that track repairs were under way at the place of the accident; that the foreman of the track repair gang was not informed that the "special" was to go over the division; and that no signals were placed to warn an approaching train of the repair work. A brief account of the wreck was published in our issue of May 4.

RAILWAY ACCIDENT BULLETIN NO. 38, recently issued by the Interstate Commerce Commission, gives statistics for October, November and December, 1910. The number of persons killed in train accidents during that period was 248 and 3,729 were injured. Compared with the preceeding quarter, this shows a decrease of 73 in the number killed and of 163 in the number injured. On electric lines, including only those carrying interstate traffic, 114 persons were killed and 1,031 injured, showing a decrease, compared with the previous quarter, of 34 in the number killed and 119 in the number injured.

In accidents of all kinds, excepting "industrial" accidents, a total of 2,659 persons were killed and 19,927 injured. About one-third of those killed and nearly three-fourths of those injured were railway employees. In addition the "industrial accidents," including only those in which no moving engine or car is involved, killed 107 persons and injured 20,394, all employees.

Of the total number of derailments, which was 1,532, nearly half (709) were due to defects of equipment and about one-fifth were due to defects of track or roadway. The total number of collisions was 1,834.

THE CLOSING PILE IN ONE OF THE CYLINDERS making up the cofferdam which surrounds the wreck of the U. S. S. "Maine" failed during driving on May 8. This is the second of the 50 cylinders in which this accident has occurred. The sheet piles are driven in the circle to a closure opening which is filled by a final pile. In these two cases the spread has been too great for the pile which was intended to fill it and the circumferential tension in driving has been great enough to part the jaws of the sheet pile. It is expected that the damage will be easily repaired.

THE DAM AND LOCK ACROSS THE HUDSON at Troy, N. Y., which were authorized by the River and Harbor Bill last June, are to be held up pending the final outcome of a recent decision of the New York State Canal Board. It will be remembered that the Canal Board of the previous administration, with the approval of Gov. Hughes, thought that the construction of the dam at Troy and the development of the river there to a depth of 12 ft. should be carried on by the federal government, and for the past two years the State of New York, through its accredited agents, has been earnestly and repeatedly soliciting the federal authorities to undertake this work. The Chief of Engineers has reported that in his opinion the construction of such a dam and the development of the river to the extent required were not absolutely necessary at the present time, but that, if the federal government should undertake the regulation of the river with the construction of the dam and lock, it should be required of the State of New York that it give up all rights to the water power developed at this dam. This water power at present consists of some 1,800 HP., but can be raised to about 6,000 HP. by a properly located dam. Under an old contract, all the power rights here are held by the Troy Hydraulic Co., which for a great number of years has been paying the nominal sum of $300 a year for the power use. The federal authorities did not anticipate any great profit from the power which they could get from the new dam, but required the relinquishment of New York State's rights because they did not wish to be hampered with any suits or controversies with the corporation holding the previous water rights.

The previous Canal Board agreed to the federal government's demands, and in an order passed by it and signed by Gov. Hughes, relinquished all its water rights at the site. The then Attorney-General of the State reported that such a proceeding was perfectly legal. Acting upon this first order, the federal congress authorized the appropriation of somewhat over $5,000,000 for the regulation of the river above Troy and the construction of the lock and dam there. It is stated that about $1,000,000 of this sum was to be applied to the dam and lock and the other $4,000,000 to the regulation of the river proper, which under any circumstances it would be the duty of the federal government to care for. Under that part of this appropriation now available, some contracts have already been entered into and work was about to be started on the construction of dikes and in dredging. The location of the dam, however, was in dispute and is now before the Secretary of War for decision.

The manufacturers at Troy, operating under the name of the Troy Hydraulic Co., naturally were opposed to this signing over of their very cheap water rights, but their protests had no effect on the recent administration. When the present administration came in, however, they re-presented their claims with more success. The present Canal Board last month decided, under the advice of the present Attorney-General, that the state had no right to sign over the water rights granted this company and that it was contrary to the best policy of New York State to give to the federal government control of any of the water rights in the state. It therefore recommended, and its recommendation was signed by Gov. Dix, that the agreement with the federal government should be rescinded. At present this order is in the hands of the Secretary of War, upon whose action all future disposition of the case depends. The work on the dam and river improvement is being held up until he makes a decision.

It is understood that the federal government is perfectly willing to turn over to the State for a nominal sum all the water power generated by the government dam.

TELEPHONE COMMUNICATION from New York City to Denver, Colorado, has very recently been commercially established. In order to make this service possible over a line of 2,011 miles, the insulation of the lines had to be increased by using improved insulators, heavier wire on some sections, and by installing, at intervals of about eight miles, Pupin "loading" (inductance) coils to prevent distortion and attenuation of speech.

NEGOTIATIONS FOR NEW SUBWAY CONSTRUCTION in New York City, which have been going on for some six months between the city and various corporations, recently brought a well-planned offer from the Brooklyn Rapid Transit Co., and this in turn has now elicited a counter-offer from the Interborough Rapid Transit Co. which appears much more advantageous to the city than the company's earlier offers. The Interborough company, operating the existing subway, is favored by Mayor Gaynor and some other of the city officials, on the theory that a subway network under one operating management is better for the public than two or more independent subway systems. The new Interborough offer has as its main constructive elements:

(1) A subway in Lexington Ave., Manhattan, north from 42d St., with Bronx branches of elevated construction to Jerome Park and Pelham Bay Park, and a subway south from 42d St. along Seventh Ave., Varick St. and West Broadway, with an East River tunnel at Liberty St. to Brooklyn; these two subways being combined with the existing one to form separate east side and west side lines traversing Manhattan from south to north and each connecting Brooklyn with the Bronx. (2) A subway through Williamsburgh, Brooklyn, west under the East River and 14th St. to Broadway, Manhattan, thence via Broadway and 59th St. to the Queensboro (Blackwell's Island) Bridge and across the bridge, terminating in short northerly and easterly elevated extensions in the borough of Queens, with connection also to the east end of the Steinway (or Belmont) tunnel. (3) An elevated extension of the east side Bronx branch of the present subway northward along White Plains Road about three miles. (4) Extensions of the Brooklyn end of the present subway southeast along Flatbush Ave. and Eastern Parkway, and east along Lafayette Ave. to a junction at Bushwick Ave. with the line mentioned under (2). Operation of the Brooklyn Fourth Ave. subway (now under construction) and via Manhattan Bridge to the Center St. loop subway (completed) is also proposed.

The principal financial elements of the proposal are as follows: The city and the company contribute each about $68,000,000 construction cost, and the company expends about $32,000,000 equipment cost, the total expenditure thus being about $168,000,000. The earnings of all the new lines, after paying operating and fixed charges, go to the city for five years, and thereafter go to the company except that if there is any loss to the city on the Fourth Ave. line the company turns over all net earnings after deducting an additional 3% return on its investment, this division of profits to continue until the city has evened up its loss. The Fourth Ave. line is to be guaranteed by the city, i. e., the expected deficit on this line is to be paid by the city to the company. All extensions of the complete system as now proposed are to be similarly guaranteed by the city.

An essential feature of the Interborough offer is that, like the company's previous offers, it is made contingent on permits for laying a third track on certain parts of the existing elevated railways, to permit of operating express trains the full length of the Second and Third Ave. elevated lines. The franchises for these third tracks are to be virtually perpetual. The city is to receive therefor 2% of the increase in gross receipts at the express stations of these elevated lines.

MOTOR DRIVES IN A PORTLAND CEMENT MILL.—In the plant of the Allentown Portland Cement Co., at Evansville, Pa., opened a year ago, are seen many features of interest in the arrangement of machinery and the induction-motor drives. This mill has a capacity of 2,500 bbls. per day, and can be enlarged on the same lines to 5,000 bbls. Two quarry hoists are driven by a 5-HP., 750-r.p.m. motor, with a coil-wound rotor for easy starting. In the first crushing house, a line-shaft drive from a single 250-HP. motor, has been used instead of individual motors, in order to equalize the intermittent loads and to eliminate shocks on the motors. Three 7 × 56-ft. rock driers are driven from a line-shaft by one 50-HP. motor. Additional speed change is secured by a set of bevel gears and two sets of spur gears. In the raw grinding house, two ball mills are driven by one 40-HP. motor. In the Fuller mill-house, eight 42-in. machines are individually driven by 75-HP. vertical motors, which have been found advantageous, in comparison with horizontal motors and quarter-turn belts. The two coal pulverizers require a single 75-HP. motor, and each kiln is driven by one of 30-HP. placed in a pit under the kiln-house floor. The drive is through two belts, one set of bevel gears and two of spur gears. The kilns revolve very slowly, making a revolution in from 1 to 1½ minutes, and it is necessary to vary this speed to suit the charging and firing conditions. Induction motors, with coil-wound rotor connected through slip rings to rheostats, have been used here. Four rotary clinker coolers are operated from a single 50-HP. motor. There are eight Fuller-Lehigh mills in the finishing house, and each is driven by a 75-HP. vertical motor, as in the raw grinding. There are four bagging machines, driven by two 30-HP. motors. The many bucket and belt conveyors are driven singly and in groups by motors varying in capacity from 10 to 40 HP. This plant was constructed by the Fuller Engineering Co., of Allentown, Pa., and the electrical equipment was furnished by the Westinghouse Electric & Manufacturing Co., of Pittsburg.

AN ACCIDENT IN THE LA SALLE ST. TUNNEL, Chicago, on May 3, resulted in the death of two men and the injury of four others. The accident occurred in that part of the south approach which is being driven by tunneling from a shaft near the river (at South Water St.) to that part of the approach which has been built in open cut. A central working drift is driven at the level of the invert, and at 30-ft. intervals cross drifts are formed, and longitudinal drifts driven for the side walls and roof. These side drifts are 10 ft. long, and after alternate sections are completed the intermediate sections are excavated and completed. The haunches on each side are almost directly beneath the side walls of the old tunnel (at a higher level). A gang was at work at the end of one of the cross drifts, excavating beneath the old masonry invert and wall, which masonry had a length of only 12 ft., having been cut by the two adjacent sections of the new tunnel. It is reported that not enough attention had been given to shoring up this masonry, though the foreman stated that he had warned the men. At any rate, a mass of this old masonry which had been undermined broke loose and fell into the drift, crushing the men. One man was killed outright and another died later from his injuries.

THE PATENT AGREEMENT of The General Electric and Westinghouse companies which has held in force since 1896, expired on April 30, it is announced, and will not be renewed. It will be remembered that this agreement was entered upon when these companies held many patents whose claims overlapped, more or less, so that difficulty was found on both sides in designing apparatus without danger of litigation. As a result neither interest secured its full rights and advantages. A Board of Patent Control, made up of representatives of both interests, fixed the terms of mutual licenses. As many of the principal overlapping patents have expired, the situation is again simplified. Either company may still license the other, however, if a like situation arises again.

Personals.

Mr. Edward Groves, City Engineer, of Ann Arbor, Mich., has resigned.

Mr. F. L. Stone, Engineer of Track Elevation of the Chicago, Burlington & Quincy R. R., has resigned to engage in other business.

Mr. F. S. Broadhurst, recently with the Westinghouse Machine Co., has become Sales Manager for the C. H. Wheeler Mfg. Co., of Philadelphia, Pa.

Mr. Chapin E. Harris, for the past three years Assistant Engineer with the New York State Highway Commission, has been appointed City Engineer of Norwich, N. Y.

Mr. J. C. Woodsome, until recently Superintendent of the Dallas (Tex.) Electric Light & Power Co., has been appointed General Manager of the Tampa (Fla.) Electric Co.

Mr. J. A. Trawick, formerly General Manager of the Tampa (Fla.) Electric Co., has been placed in charge of the hydroelectric development now under construction at Keokuk, Iowa.

Mr. Carl C. Witt, M. Am. Soc. C. E., has resigned as Engineer for the South Dakota Board of Railroad Commissioners to become Engineer for the Public Utilities Commission of Kansas, at Topeka, Kan.

Mr. Charles J. Jones, Chief Engineer of the Aurora, Elgin & Chicago Ry., has been appointed General Superintendent in addition to his position as Chief Engineer. He will make his headquarters at Wheaton, Ill.

Mr. George A. Damon, Assoc. Am. Inst. E. E., Managing Engineer of the Arnold Co., Chicago, Ill., has been appointed Dean of the School of Engineering of the Throop Polytechnic Institute, Pasadena, Cal.

Mr. John S. Nicholl, formerly Acting Manager for F. W. Horne, importer of American machinery, Yokohoma, Japan, has joined the staff of Mr. Walter B. Snow, M. Am. Soc. M. E., Publicity Engineer, of Boston, Mass.

Mr. Ralph Hamlin, Assoc. M. Am. Soc. C. E., formerly Designing Engineer with the Corrugated Bar Co., of St. Louis, Mo., has resigned to accept a position as Chief Engineer of the firm of Pike & Cook, General Contractors, Minneapolis, Minn.

Mr. J. W. Mulhern, Superintendent of the Western Division of the Western Pacific Ry., at Sacramento, Cal., has been appointed General Superintendent of the Utah Lines of the Denver & Rio Grande R. R. at Salt Lake City, Utah, succeeding the late J. C. Dailey.

A monument commemorating the work of Dr. Alexander Graham Bell, Past-President Am. Inst. E. E., inventor of the telephone, will soon be erected in his birthplace, Brantford, Ont. It is expected to have the formal celebration on Dominion Day, 1912.

Mr. John F. Wallace, Past-President Am. Soc. C. E., President of the Electrical Properties Co., of New York City, has been elected President of Westinghouse-Church-Kerr & Co., of New York City, succeeding Mr. H. H. Westinghouse, who retires to give his attention to his other interests.

Mr. T. Quigley, formerly Assistant Engineer of the Yazoo & Mississippi Valley R. R., has been promoted to Supervisor of the Baton Rouge District, with headquarters at Baton Rouge, La. Mr. O. T. Dunn, Assoc. M. Soc. C. E., has been appointed Assistant Engineer to succeed Mr. Quigley.

Mr. W. M. White, M. Am. Soc. M. E., formerly Hydraulic Engineer with the I. P. Morris Co., of Philadelphia, Pa., has become associated with the Allis-Chalmers Co., of Milwaukee, Wis., as Manager and Chief Engineer of their Hydraulic Turbine Department. During the last five years, Mr. White has had charge of designing some of the largest turbine installations in this country, including those of the Toronto Power Co., at Niagara Falls; the Great Western Power Co., of California; and the Washington Power Co., of Spokane, Wash.

Mr. Charles N. Monsarrat, M. Can. Soc. C. E., has been appointed Chairman and Chief Engineer of the Board of Engineers, Quebec Bridge, to fill the position left vacant by the resignation of Mr. H. E. Vautelet, M. Can. Soc. C. E., in February last. Mr. Charles Macdonald, M. Can. Soc. C. E., has also severed his connection with the Board, one of the conditions of his consenting to act being that he be allowed to retire when the contract was signed. Mr. Monsarrat and Mr. Modjeski now compose the Board, with the vacancy caused by Mr. Macdonald's retirement yet to be filled. Mr. Monsarrat has had a wide experience as a bridge engineer, and has, for the past nine years, been Engineer of Bridges for the Canadian Pacific Railway.

Obituary.

Niels Poulson, President of the Hecla Iron Works, of Brooklyn, N. Y., died at his home in Fort Hamilton, Brooklyn, on May 3. He was born in Horsens, Denmark, in 1843, and came to this country in 1864. For a time he was a draftsman in the office of the Supervising Architect of the Treasury Department at Washington, D. C. In 1876 he started in the architectural iron business with Charles M. Eger, and in 1897 the business was incorporated as the Hecla Iron Works. Mr. Poulson was a broad-minded and public-spirited citizen, and much of his time and means were given to educational and philanthropic interests.

Sidney M. Bamberger, President and General Manager of the Salt Lake & Ogden Ry., died at his home in Salt Lake City, Utah, on May 9. He was born in Germany in 1848. He entered the railway service in this country in 1869, and was for many years employed with construction work on the Missouri Pacific and the Union Pacific Railroads. In 1882 he became President of the Great Salt Lake & Hot Springs Ry., and in 1896 President of the Salt Lake & Ogden Ry. Aside from his railway work he was prominent as a director and officer of several industrial and banking companies of Salt Lake City.

Francis B. Clarke, formerly Vice-President of the Spokane, Portland & Seattle Ry., died at Portland, Ore., on April 25. He was born in Madison County, N. Y., on July 1, 1838. In 1868 he began railway work with the Wisconsin Central R. R., of which he became General Freight Agent in 1872. In 1878 he was appointed General Traffic Manager of the Chicago, St. Paul, Minneapolis & Omaha Ry. In 1896 he was General Traffic Manager of the Northern Steamship Co., and later of the Great Northern Ry., which position he held until 1904. In 1908 he went to Portland to take charge of the Hill railway interests as President of the Spokane, Portland & Seattle Ry. Two years later he resigned this position on account of ill health.

Hilon A. Parker, for many years connected with the engineering and operating departments of the Chicago, Rock Island & Pacific Ry., died at Chicago on May 3. He was born at Plessis, N. Y., in 1841, and served through the Civil War. He went to Chicago in 1866 and entered the engineering department of the above railway as a chainman. Subsequently he became Resident Engineer, Division Engineer and Chief Engineer of different portions of the system. During 1888-1890 and 1893-1898, he was Assistant to the President; he was Third Vice-President, 1890-1893; second Vice-President, 1898-1899; and First Vice-President and General Manager, 1899-1903. It is stated that since his resignation from the Chicago, Rock Island & Pacific Ry., in 1905, he had been Consulting Engineer for some of the work of the Grand Trunk Pacific Ry.

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
May 17. Semi-annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, STEAM AND ELECTRICAL ENGINEERS.
May 18-19. Annual convention at Youngstown, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 23-25. Annual meeting at New York City. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

AIR BRAKE ASSOCIATION.
May 23-26. Annual convention at Chicago, Ill. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 23-26. Annual convention at Pittsburg, Pa. Secy., Richard Moldenke, Watchung, N. J.

INTERNATIONAL MASTER BOILERMAKERS' ASSOCIATION.
May 23-26. Annual convention at Omaha, Neb. Secy., H. D. Vought, 62 Liberty St., New York City.

NATIONAL GOOD ROADS ASSOCIATION.
May 23-26. Annual congress at Birmingham, Ala. Secy., Anna M. Grady, Hotel La Salle, Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 29-June 2. Annual convention at New York City. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 30-June 2. Annual convention at Pittsburg, Pa. Secy., Calvin W. Rice, 29 West 39th St., New York City.

ENGINEERS' SOCIETY OF PENNSYLVANIA.
June 6-8. Annual meeting at State College, Pa. Secy., E. R. Dasher, P. O. Box 704, Harrisburg, Pa.

AMERICAN INSTITUTE OF MINING ENGINEERS.
June 6-10. Annual convention at Glen Summit Springs Hotel, Luzerne Co., Pa. Secy., Joseph Struthers, 29 West 39th St., New York City.

AMERICAN WATER WORKS ASSOCIATION.
June 6-10. Annual convention at Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 13-16. Annual convention at Chattanooga, Tenn. Secy., Charles W. Hunt, 220 West 57th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-16. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 19-21. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-23. Annual Convention at Boston, Mass. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 26-30. Annual convention at Chicago, Ill. Secy., Ralph W. Pope, 33 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN CHEMICAL SOCIETY.
June 28-July 1. Annual convention at Indianapolis, Ind. Secy., Charles L. Parsons, Durham, N. C.

ATLANTIC DEEPER WATERWAYS ASSOCIATION.—The fourth annual convention will be held at Richmond, Va., in October, 1911.

CLEVELAND ENGINEERING SOCIETY.—A paper on "The Various Applications of the Electric Storage Battery" was presented at the meeting of May 9 by Mr. C. W. Chappelle, Chief Engineer of the Electric Storage Battery Co., Philadelphia.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Atlantic City has been chosen as the place for the 1911 convention, which will be held Oct. 9-13. The 1912 convention will probably be held in Chicago. This association was formerly the American Street and Interurban Railway Association.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—A catalog exhibit will take the place of the usual exhibition at the convention in New York City, May 29-June 2. The exhibit will be held on the fifth floor of the Engineering Societies' Building. Applications for space must reach the secretary not later than May 15.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Mr. W. P. Cutter, formerly librarian at Forbes Library, Northampton, Mass.; has been appointed librarian of the society. Mr. Cutter has made a national reputation for the Forbes Library by increasing the number of books consulted per capita above that of any other library. Extended researches will be undertaken for members, at a charge corresponding to the actual cost of the service, and simple inquiries will be answered without charge.

OHIO SOCIETY OF MECHANICAL, STEAM AND ELECTRICAL ENGINEERS.—At the annual convention at Youngstown, Ohio, May 18-19, papers will be presented as follows: "Flue Gas Analysis," Joseph W. Hays, Chicago, Ill.; "The Engineering Features of the Columbus Garbage Reduction Plant," Irwin F. Osborn, Columbus, Ohio; "Industrial Motor Control," D. Martignone, Cleveland, Ohio; "Hydro-Electric Development in the Central West," Paul M. Lincoln, Pittsburg, Pa.; "Centrifugal Blowers," Dr. Lowenstein, Schenectady, N. Y.

THE NEW YORK ELECTRICAL SOCIETY.—The 301st meeting was held April 28 in New York City. Mr. Frank A. Pattison lectured on "The Electrical Equipment of the New York Public Library," after which a visit of inspection was made by the members to the library building. Resolutions were passed tendering the Society's sympathy to the families of Joseph Wetzler and of Charles Wallace Hunt, recently deceased. Mr. Wetzler was a Past-President of this society. A testimonial was presented to Mr. H. A. Sinclair in recognition of his faithful work as Treasurer of the society for a period of 25 years.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the meeting in New York on May 16 for the presentation of The Edison Medal to Mr. F. J. Sprague several addresses will be made on electric railway and naval electric developments. The speakers and subjects announced are as follows: "The Development of The Electric Railway," by Mr. W. B. Potter, of Schenectady; "Social Results of the Introduction of the Electric Railway," by Prof. T. H. Giddings, of New York City; "The Relation of Governmental Control to the Development of Electric Railways and the Electrification of Steam Lines," by Prof. G. F. Swain, of Cambridge, Mass.; "The Results of the Use of Electricity in the Navy," by Commander S. S. Robinson, Bureau of Steam Engineering, Navy Department.